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TRANSACTIONS

OF

THE CERAMIC SOCIETY

INCLUDING

THE REFRACTORY MATERIALS SECTION.

Founded in 1900 as "The North Staffordshire Ceramic Society,"
and continued from 1903 to 1916 as
"The English Ceramic Society."

VOLUME XIX.—SESSION 1919-20.

Authors are alone responsible for the Opinions expressed in their papers.

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RULES.

1.—The Society shall be called THE CERAMIC SOCIETY. It shall comprise a special section dealing with Refractory Materials.

2.—The object of the Society shall be the discussion of all subjects relating to the industries connected with Clay Working and Refractory Materials.

3.—Persons desirous of membership shall be proposed and seconded by two Members of the General Meeting, and they are then eligible for election at the next Committee Meeting.

4.—The Society shall be governed by a President, Vice-Presidents and Council, a Librarian, a Secretary, and a Treasurer. The Officers shall be elected at the last General Meeting of each Session, and hold office until the last General Meeting of the ensuing Session, when they shall be eligible for re-election. Among the Vice-Presidents shall be included all past Presidents who are subscribing members of the Society. A Chairman of Council shall be appointed by the Committee.

4a.—The Council shall consist of officers, Ex-Presidents, and twelve members, of whom four shall resign each year, the retiring members to be eligible for re-election.

4b.—Two additional members of the Council, one of whom will also act on the Publication Committee, shall be elected by the Federation of Pottery Manufacturers.

5.—The headquarters of the Society shall be the Central School of Science and Technology, Stoke-on-Trent.

6.—The Meetings shall be fixed from time to time as arranged by the Sectional Committees. At Stoke-on-Trent the Meetings during the Session are usually held at 7-30 p.m. on the second Monday of the month.

7.—The annual subscription shall be payable in advance, and shall be fixed from time to time by the Committee (25/- for 1919-20). Members of the Society who have paid their annual subscription receive a copy of the TRANSACTIONS free.

8.—A firm can join the Society by paying an annual subscription of two guineas. For this subscription the attendance at each meeting shall be limited to three members of the firm, and one copy of the TRANSACTIONS will be supplied free annually.

9.—New members shall pay an entrance fee of one guinea.

10.—Students may be elected to Student Memberships without paying an entrance fee. Their subscription shall be 5/-, and will entitle them to attend the meetings, but no TRANSACTIONS will be supplied. After twelve months membership, a Student can be elected to full membership without payment of entrance fee. The Council shall decide whether a person is eligible for a Student Membership.

11.—Notification of meetings shall be sent by post to each member in Great Britain with the name of the subject of the paper for discussion.

12.—In the discussions arising upon any paper, no speaker shall occupy more than ten minutes, or make more than one speech, except by the permission of the Chairman.

13.—Any property of the Society lent to members must be returned within a week.

14.—Any member promising a paper and failing to keep his appointment shall himself provide a substitute.

15.—The Society shall have the prior right of publication of all papers read before it for a period of three months.

16.—Authors must send their papers to the Society before or immediately after the communication has been read. If received in time the paper may be printed in time for the meeting. The official receipt of any paper will be dated from the time it is received by the Secretary.

17.—Members may obtain one copy of each of the back numbers of the TRANSACTIONS at subscription rates, providing they are for their own personal use, and that the number in stock be over 18.

18.—Members who are three years in arrear with their subscriptions shall be informed by means of a printed notice, and if the arrears are not paid within a month their names shall be struck off the list. *New Members are put on the list of members when their subscriptions have been paid.*

19.—A member of the Society may introduce a visitor to an ordinary meeting. A visitors' book is kept to show what non-members are present, and by whom they are introduced. The names of the visitors are read out by the Chairman at the opening of the same meeting.

20.—No alteration or addition to the above Rules shall be made except notice be given in General Meeting, and passed by the ensuing General Meeting. Ten to form a quorum.

I.—Molecular Force and Plasticity of Clays.

By Herbert Chatley, D.Sc. (Lond).

In a series of papers to the Physical Society, the writer has advanced two hypotheses:—

(1) That molecular attraction can be regarded as continuous with gravitation, the negative index of variation of the distance being itself a function of the distance. He has suggested a hypothetical expression:

$$t_2 = g.m_1.m_2.d^{-(2+\frac{n}{k})}$$

Where t_2=attraction between two molecules
g=gravitation constant
m_1, m_2=masses of the molecules
d=distance between centres of molecules
n=coefficient between 4 and 5
k=ratio of d to d_0, the distance between the molecules at absolute zero (=sum of effective radii).

(2) That molecular attraction is due to "stray field" which remains when the atomic forces are balanced. (This agrees with Sutherland's "electric doublet" hypothesis). Such stray field is necessarily vectorized and the expression given above expresses the average value of the attraction for all possible juxtapositions of a pair. From various sources it appears that the attraction of a molecular pair is about 10^{-6} dyne and the potential of a separated pair about 10^{-15} erg so that the effective range of the force is 10^{-9} centimeter. On this hypothesis the attraction between molecules diminishes with great rapidity as the distance is increased and speaking practically only the pairs which are immediately juxtaposed will exert any appreciable force. Hence any one grain or small aggregation of molecules (within which there is tensile strength since all the molecules are in close proximity to others) will only attract others at the points of sensible contact and the force acting on each such particle will not exceed a small integral number of molecular bonds.

If we say ten such act on each particle congruously, then the total force is approximately 10^{-5} dyne. If the weight of the particle or other force acting on it is less than or of the same order

as this molecular force, the particles will exhibit plasticity.

Thus, a particle whose volume is 10^{-10} cubic centimeter (say 10^{-3} cm. diameter) has a weight of say $2{\cdot}5 \times 981 \times 10^{-10}$=say $2{\cdot}4 \times 10^{-7}$ dyne, and will show plasticity because its weight is much smaller than the probable molecular force. Similarly for all smaller sizes of particle.

If, on the other hand, the volume is 10^{-6} cubic centimeter (say 10^{-2} cm. diameter), the weight is say $2{\cdot}4 \times 10^{-3}$ dyne and greatly exceeds the probable molecular force so that a structure of such particles will not be stable, *i.e.*, is not plastic.

The suggestion is then that plasticity (and also when the molecules of the fluid are considered the specific "colloid" properties of sub-divided matter) is due to the presence of molecular forces comparable with weight or other external agency.

II.—Fine Grinding No. 2. The Influence of the Shape of the Particle; being a Supplemental Paper to that read by the author in November, 1914.

By L. G. Hill, F.R.S.A., M.S.W.I.E.

It was with much gratification that I received Dr. Mellor's invitation to read you another paper on Fine Grinding; and I hope the present effort will result in as interesting a discussion as did my attempt in November, 1914.

Without laboring the claims I then advanced, I will venture to quote an opening remark "One of the difficulties in the way so far has been that of getting the material into a sufficiently fine state of division,'' and that paper of 1914 claimed that fine grinding could be attained by the Griffin Mill, more economically than by wet grinding or Ball Cylinder or edge runners.

This has since been proved to be correct by several firms who have adopted this system—and the advantages claimed for this system have been realised, viz:—

Reduced cost of grinding.
Considerable saving of floor space.
A superior raw material resulting in more regular manufacture, consequent reduction in spoilt goods.

In the discussion Mr. Moore described my samples as "not finely ground,'' claiming that 180s lawn was desired. In our subsequent operations we have always been asked for 120s lawn —I will refer to this feature later.

The extraction of metallic particles (resulting from wear and tear of the mill) has been satisfactorily attained by your usual system of magnetic separation.

The difficulty of a dust laden atmosphere has been successfully overcome by the installation of a small dust collector.

The use of these mills in the U.S.A. was at that time an unknown quantity to me, but this question may be answered by the fact that the Continental Potters use this mill considerably. One pottery in Germany having installed fifteen giants and five 30-inch mills since 1914.

Since the meeting in November, 1914. Several of these Mills have been introduced into your Industry in this Country with apparently satisfactory results, we have had repeat orders.

In the plate-glass manufacture where added metallic particles is above all things to be avoided, we ground as a test Fontainbleau sand to pass 120s mesh—the test showed an addition of ·025% of iron particles which was readily extracted by the magnetic separator—one of our Improved Giant Mills is installed and giving satisfaction.

Here, however, I ask your careful consideration and discussion —this Fontainbleau sand was very fine, probably all would pass a 20×20 originally but it was all "spheroidal" particles; by putting it through a Griffin Mill it was broken up into "angular" particles as I will demonstrate on the screen.

I have tested very many systems of grinding and it is only the Griffin Mill which will give an "angular" particle. I claim that this "angular" particle should show a decrease in your kiln-cracked goods, as compared with bodies composed of "spheroidal" particles, never mind how finely ground.

I propose that when a body containing a large percentage of "spheroidal" particles is submitted to the heat of our kiln, contraction takes place, and a crack occurs owing to "spheroids" not being able to interlace as they contract—You cannot make concrete with marbles.

On the other hand when the "body" is composed of "angular" particles (even if some of them are comparatively coarse, say not quite 120s fine) on contraction in the kiln they all knit together and the crack does not occur. This is a feature well worth your consideration, and I have prepared slides of several systems of grinding which will illustrate my meaning.

Should this theory be well founded as I have confidence that it is—the Griffin Mill should be instrumental in saving a big lot of your present waste, whether in Earthenware, China, Tiles, Bricks or Sanitary Ware.

I propose that a body composed of "angular" particles should be more plastic than one composed of "spheroids." I venture to suggest that an intricate detail of this nature has been appreciated by the German in his adoption of the Griffin Mill for treating so many of his refractory minerals, and I am justified in saying that the several instances where Griffin Mills have been adopted in the Ceramic industries in this Country have been satisfactory.

In my previous paper, it was proposed that "materials used" in this industry have to be fluxed by chemical means or heat—and that the finer and more complete the system of grinding attained the better the resulting chemical or other process following.

In the discussion following I was informed that my proposed system would not be considered "fine grinding" in the Ceramic Industry—and that in well-ground materials there would be no "residue" on 180s lawn.

Gentlemen, am I right in assuming that most of you are

familiar with this flaw in most sorts of ware on examining the Kiln after burning? I am not informed as to the percentage of goods spoiled during the first burning; you as practical men appreciate the fact that all your skilled work is expended on the plastic material and the slightest damage experienced during the kilning, causes the entire piece to be useless—it is not so many lbs. or cwts. of raw material which is lost, but so many pounds sterling worth of manufactured goods destroyed—a much more serious matter. And if I am able to suggest to you a means of reducing this loss, I am sure you will hear my probably very elementary suggestions with consideration.

Should this suggestion prove correct in practice, your production would be increased by the percentage of breakages avoided by the adoption—you are better able to judge if that is worth while by viz. —so many more sound pieces than at present obtained, instead of so much manufactured goods destroyed. You thus obtain a very increased production without the necessity of increasing materially your Capital outlay for plant—you save the loss at present incurred in "destroying manufactured goods." I trust I have made my proposition clear. I mentioned just now the Germans had probably considered this matter of the "shape of the particle." I here produce an advertisement from the German Pottery Gazette. You will observe this firm who are the licensed makers of Griffin Mills in Germany, advertise that 200 of these Giant Mills are engaged in production.

And I have it on first hand authority that the 1st Griffin Mill was introduced in the German Glass Industry 20 or 25 years ago—and I have already mentioned that 15 giants and 5 small Griffin Mills have been installed in one German Pottery since 1914—I need not comment further on this, but leave it to your keen consideration.

To illustrate my meaning as to the shape of the infinitesimal particle, I will show you an actual cloud of this grinding floating in the atmosphere almost like smoke.

And now an enlarged view (150 magnifications) of that smoke is on the screen. You will observe these are all "angular," no "spheriods." Now a few slides of other systems of grinding will be shown.

I propose that within certain limits of coarseness, say, all to pass a 100 × 100 mesh would not be too coarse for china-ware (tea service being the thinnest) provided you are free from "spheroidal" particles, this angular particle will tend to reduce if not entirely eliminate your cracks in the "Kilning."

May I conclude with a rather humorous photograph taken from the American Pottery Gazette, probably you are familiar with it, and ask you to be as busy as the boy in concentrating your practical attention on the facts and points I have taken the opportunity and privilege of laying before you.

DISCUSSION.

Mr. J. A. Audley:—It is our custom, when a paper is read by a gentleman who is not a member of the Society, for a vote of thanks to be passed to the essayist for his services. It is with great pleasure on the present occasion that I rise to propose a vote of thanks to Mr. Hill for his second paper on "Fine Grinding." Whatever discussion the paper may give rise to, and whatever differences of opinion may be brought out in that discussion as regards some of the statements made by the reader of the paper, such discussion is always to the good. I remember that at the Middlesbrough meeting of the Refractory Materials Section Dr. Stead, who presented a paper on that occasion, in the course of his remarks at the conclusion of the subsequent discussion, made the statement that if one wished to learn anything one should read a paper on the subject in question, for the discussion which followed the reading of a paper often brought out points of more importance than the paper itself. Whether that is going to be the case in regard to the present paper remains to be seen. But Mr. Hill has put before us some morsels for consumption which may have a good result. I move that our best thanks be given to Mr. Hill for his paper.

Mr. A. Leese:—I have very great pleasure in seconding the vote of thanks. I think it is very kind of Mr. Hill to come forward a second time to give us the benefit of his experience in the matter of grinding by the Griffin process, and I have no doubt that it will promote a good deal of discussion, which I hope will be of a useful kind.

Mr. F. Turner:—I certainly agree with the lecturer in one or two of his remarks. I think the majority of the potters present will be familiar with the fact that the question of angular or spheroidal particles in our ground material is of considerable importance. The difference in the working properties of a clay with spheroidal particles and one with angular particles is considerable, both as regards plasticity and tensile strength, and this being the case, one would naturally expect that the loss with angular particles would be considerably less, both in drying and firing. Certainly I agree with the lecturer there. I am not quite sure, however, that I agree with him that the method of milling at present used by potters produces spheroidal particles, and I question this even in the face of the slides. I remember some years ago there was apparently a considerable difference between the results of cylinder and pan grinding. Probably you will remember that it was argued that the difference mainly arose because in cylinder grinding one got marbles, whereas in pan grinding the result was a beautiful angular formation. In the early days of the Society Messrs. Jackson and Lethbridge read a paper, in connection with which a number of slides were shown giving the results of a considerable

amount of work, which proved that both cylinder and pan grinding produced angular particles That is rather different to what the lecturer has been telling us to-night. In view of these facts are the slides quite conclusive that our modern methods of milling produce the spheroidal particles? They may produce some: possibly even the Griffin mill may produce a few. I am sorry not to see eye to eye with the lecturer on this point. There was another statement, too, which I am disposed to question, and that was that the amount of iron which was introduced—and I think the lecturer admitted that it was fairly considerable, considering the effect of metallic iron in pottery bodies—had been successfully taken out. I cannot quite see this being done by the ordinary horseshoe magnets used on our potteries. Then the lecturer mentioned something about 30 cwts. of pitchers being sent to the tip at a time. But surely that was not the product of a single oven! I should think any manufacturer could do better than that. Even if they could not, I do not know that this would be entirely due to want of plasticity or of tensile strength in the clay. If it were, then it is time that they tried to remedy it in some way. If I remember rightly, Mr. Ramsden suggested, when the lecturer read his previous paper, that we should have some rather more definite figures as to the fineness of particle yielded by the Griffin mill. When you speak of a 120's or 180's lawn, it does not really convey a great deal. It simply tells how much of the material will not pass the lawn: it does not tell us the fineness of that which actually passes the lawn. It was suggested that samples of ordinary potters' materials should be ground in the Griffin mill and elutriated, so that effective comparisons could be made between the results of the two systems of milling. Potters do like to handle hard facts, and they would be particularly interested to see the results of a number of their ordinary materials ground by the Griffin process and elutriated in the Schöne or some other elutriating apparatus. Again in dealing with pottery bodies we naturally slip them. Has the lecturer had any experience of adding material ground in a Griffin mill in the dry state to a potting slip? Experience generally has shown that the addition of dry material to a slip does not make for plasticity. Are the results different with the material ground in a Griffin mill? It is certainly a fact that dry ground materials coming from the ordinary cylinder mill offer difficulties in this direction. Apart from these difficulties, however, I would like to know whether anyone has actually tried adding to a slip material dry-ground by the Griffin process, and what has been the result?

I will not attempt to discuss the tile fault that the lecturer produced, beyond merely saying that other causes might have accounted for the cracking than lack of plasticity or want of tensile strength.

Mr. A. Leese:—During the discussion which followed the

reading of the 1914 paper by Mr. Hill, an invitation was extended to any manufacturer to send on a bulk quantity of raw material to be ground by this type of mill and afterwards made up into ware. I shall be glad to hear if anything was done in that direction, and what was the result.

There seems to be no doubt that the chief objection, so far as the potter is concerned, in adopting this type of milling, is that iron is actually rubbing against iron in the grinding operation. The potter's nature naturally resents the grinding of his materials in a mill which he feels certain is going to add to his troubles so far as faults from metal and oxide of iron are concerned.

Secondly, one feels conscious that he is looking for trouble not only in the making up process of different shapes and articles, but also in the drying and firing of his ware, by resorting to dry-ground materials in the body.

I would like to ask the lecturer whether the spheroidal particles are brought down to the angular formation by grinding or crushing; also what materials he has chiefly ground for use in pottery manufacture, and whether he has fired samples of the ware made up of such ground materials.

Mr. B. J. Allen:—There is no doubt that the Griffin mill is a most efficient apparatus. The fault I have to find in the mill is that for certain purposes, to which it has been applied, it is too efficient.

I propose to confine my remarks to the treatment of fireclay to be used for casting:—

Fireclay ground in a Griffin mill is much more troublesome to make into a satisfactory slip than is coarse ground material, owing to the tendency to give a "gee" formation. The action is very similar to that experienced when using osmosed clay. If the clay is kiln dried before putting through the mill the "gee" formation is much more pronounced and if a high percentage of organic matter is present you have the most troublesome material possible to make into a slip I have come in contact with. The only satisfactory method of dealing with it is to reverse the deflocculation process by adding an excess of alkali sufficient to coagulate the particles.

With regard to cracked goods, the fine grinding is likely to result in an increase of cracked and dunted ware if used for thick pieces, due to the increased contraction in firing. In this respect it resembles osmosed clay taken from the machine and without suitable treatment used for pressing.

Clay and grog ground in a Griffin mill do not give stains due to iron specks to anything like the same extent as that ground on a perforated bottom pan not because there is less iron present but on account of the fine grinding and distribution of the fine iron particles throughout the clay.

There are two purposes for which I think the Griffin mill is

ideal. First in grinding shale clay prior to deflocculation for cleaning purposes, and secondly to grind grog for the casting of refractories to be made from grog only.

With regard to the angular particles in the cloud of dust, photographs of this kind are not always truthful. You can get some varied results in photographing microscopic objects and I can not conceive it possible to get a sharp image of a round particle of colloidal dimensions and grain of the photographic plate will intensify the angularity.

Mr. W. LINDLEY:—Whilst thanking Mr. Hill for his paper, I am afraid that his suggestion that we should buy a Griffin mill and in future pack all we make is rather too Utopian. To the potter grinding is a very serious thing, entailing many considerations. I am convinced that to employ dry grinding in the dinnerware trade would be to step out for the bankruptcy court. It might not, perhaps, be the same for sanitary ware and tiles, but I am certain it would be the case in regard to dinnerware.

Mr. BERNARD MOORE:—I think, perhaps, I can add a few words of information to the discussion, but before offering these I would like to say that I have a very high opinion indeed of the Griffin mill for certain purposes. I should be very sorry, however, that its reputation should be damaged by making claims for it which it does not possess. It would be a mistake, in my opinion, if it went forth that it was the opinion of potters generally in this country that the Griffin style of grinding will do for general earthenware. In my opinion, as applied to general earthenware, it is not super-good, as Mr. Hill would seem to think. I very much doubt if dry grinding of any kind would be suitable for our purposes. I can give some reasons for expressing this view. It has been an advantage to me to have had the opportunity of seeing ground under my own supervision some few tons of material in the Griffin mill. I took samples, and have these now in my possession. 18½ cwts. per hour of hard purple stone were ground in a Griffin mill, and left a residue of 5·89 per cent. on a 100's lawn. A second trial was made, grinding at the rate of 11½ cwts. per hour, and leaving 1·43 per cent. on the lawn. If that were the only trouble the difficulty would not be a very serious one, for it would be an easy matter to remove with a sieve that percentage of coarse material. Elutriation tests reveal the fact that the percentage of the fraction below ·01 of a millimetre in both these samples was about 23%. I have found that a sample of pan-ground material which contained 32% of the fine fraction proved unsatisfactory because it was not fine enough, although there was no residue at all on a 100's lawn. Lawns such as potters use, whether they are 100, 120, or even 180, are only a measure of coarseness, they are not measures of fineness. For general earthenware at least 40% of the ground material should be less than ·01 of a millimetre. I am not making these

remarks with any sort of hostility to the Griffin Mill, because I have the very highest opinion of it and believe that it can be used effectively for some potting purposes. I should anticipate that it might be useful in the manufacture of certain vitreous bodies, but for ordinary earthenware, in my opinion, it would be against the interests of the mill itself to claim for it that it will do things it will not do. The most "fool proof" method of obtaining the fraction we want is by elutriating the material, *i.e.*, by using wash pans. I think I am right in saying that the tendency of the best practice, both here and abroad, is to wash up the material no matter how it has been ground. I know that the Griffin Mill has been used with success in some potting processes where other mills have broken down. I think there is a future for it when combined with efficient magnetting for grinding fritting materials, and possibly for preparing material for cylinder grinding, but I do not think it will ever prove suitable in the finishing of ordinary potters' material that is to be used for the manufacture of general earthenware.

Mr. R. L. Johnson:—I would like to go even a stage further than Mr. Moore has gone. He has made it quite clear that a lawn is not a test which gives a degree of fineness, but merely a degree of coarseness, and he has made the further statement that in potters' materials we require something like 40 to 45 per cent., approximately, of material which will withstand an elutriation test equivalent to a size of particle of ·01 of a millimetre. I want to go farther than that, and to say that this again is not a fineness test, but a coarseness test. In dealing with potters' materials we are apt to speak of grinding a good deal of our material not to a size but to a liquid. Now I do not see how it is possible with any invention that may be brought out to dry-grind into a liquid. There is another point that Mr. Turner touched upon, and that is plasticity. You cannot mix a dry ground silica material with water to make a plastic body.

Then Mr. Hill referred to the amount of ware which is cracked or broken in manufacture. As has already been pointed out, this breakage is not all due to the particular form in which the particles appear in the body. But if it were, it would be better to have the loss on the factory than at the other end of the world. By that I mean that we are all perfectly well aware that goods made, as Mr. Moore has pointed out, with a large percentage of coarse material will go to pieces very soon after their manufacture.

Then we come to the question of metallic particles. We are all naturally very anxious to keep impurities out of our pottery bodies, and especially metals. But if these should by any chance get in, then the only way to keep the body clean is to grind these down to a liquid. If they are left in as particles they will come out as specks. But with finer grinding they will be converted into a liquid.

With regard to the question of lawning, the lawning of a cylinder ground material has often brought trouble to a good many people. Material that has passed through a 130's lawn has been taken and reckoned satisfactory until it came to be put to the test of washing, when it was found to contain from 25 to 33 per cent. that would not withstand the finer test.

I am interested to hear that the Griffin mills are being largely used in Germany, but I think if Mr. Hill will investigate the matter thoroughly he will probably find that these mills are being used, not in china and earthenware works, but chiefly in cement works, for which I should think they would be most admirably adapted.

Mr. A. HEATH:—Perhaps Mr. Hill would be prepared to give the meeting some particulars of an elutriation which I did for him in 1914. As Mr. Moore has said, one generally expects to find efficiently ground potters' materials having a minimum of 40% of particles of diameter less than ·01 in an elutriation test. That is, in fact, a rather low estimate. I should be inclined to set the percentage at 45. If we go below 40 per cent. we are always in danger of crazing; if above 50 we are in the danger zone of dunting. As regards dry grinding in a china body, I made some time ago a number of experiments in regard to dry-ground bone. I thought that if bone was ground fine enough dry-grinding would be as good as wet. In the tests we carried out we ground both ways. We made up three bodies, (1) the ordinary body that we were using, (2) wet-ground bone passing a 120's lawn, (3) dry-ground bone through a 250's lawn. When the potter came to work these bodies he complained that it was absolutely impossible to work the dry-ground bone at all. Consequently we had to give up the idea and resort to wet milling. For a china body my experience is that dry grinding is absolutely fatal.

Mr. HILL:—First I must thank one and all for the varied reception of my paper fully endorsing our worthy Chairman's remark that "whatever discussion the paper may give rise to and whatever difference of opinion may be brought out in that discussion such discussion is always to the good."

I would remind you that in 1914 I claimed that I was neither a "Potter nor a Chemist." Some of the remarks advanced in the discussion implied that I had in the meanwhile obtained experience in the industry—such is not the case. I recognise the ceramic industry as being quite a life long job.and one requiring early and special training—my advances for your consideration have been entirely from an outsiders point of view.

In the discussion on the 1914 paper, Mr. F. Dunn said in the course of his remarks "all these alterations involve great risks that we dare not shoulder except after having made endless trials and experiments. Consequently it is only some firm, some

concern, some society I might say which could afford to undergo this ingenious system of experimental and research work that would dare to take the risk; whereas, as usual the expense of all this would have to fall on the individual manufacturers who might take it so far and then drop it either from want of time and capital or from the fear of not being successful with it ultimately."

This seems to me a very valuable suggestion; you have your own Society of men who could co-operate to carry research to a successful conclusion and a Laboratory capable of carrying out any details—what is there to prevent this being done? It is not a matter for a Government subsidy surely, such as some industries require.

Whereas, so far the Griffin Mill has been adopted by several firms individually, and I think no objections were raised to my claims by actual users of Griffin Mills.

The object of the paper was to get manufacturers interested in the theory of the "angular" particle as an advantage over the "spheroidal" particle.

Mr. F. Turner goes part way with me but not as far as he would wish. I must defer to his experience, but will hope that further research on the part of your Society will bring my views to a commercial solution. I mentioned the 30 cwt. of broken ware simply as a figure, and I do not know how often it happens—it was to call your attention to the actual value of what is a greater or lesser loss which may be reduced if looked into.

The fineness of particles, produced by a Griffin Mill are mentioned in an addition to the 1914 Paper by Mr. A. Heath as follows:

1 cm.	=42·8 per cent.
5 cm.	=30·4
Residue	=26·8

It is quite possible to obtain actual commercial samples from firms using the Griffin, so that further elutriation tests may be made.

I have had no experience in making "slip," either with dry or wet material, but I can expect there should be no difficulty in making reliable "slip" with a Griffin Mill. I do not expect the Griffin Mill to supplant all your grinding plant—it is offered to you as a very great assistant and help in improving conditions of manufacture—the Griffin Mill claims to do in 1 hour what the Wet Pan does in 12 hours. "Wet material is necessary for slip"—would it not be practicable to grind almost to slip fineness in the Griffin Mill (1 hour) and then grind in a wet pan for 1 or 2 hours to elutriation fineness? There would be a considerable saving in horse power and time, and you would retain the "angular" particle made by the Griffin.

I have advanced this method of procedure in several instances, and so I think has Mr. Bernard Moore.

In reply to Mr. Leese—within 3 weeks of the 1914 paper a

truck load of calcined flint was ground for a firm in the Potteries, the result was satisfactory as the 1st Griffin Mill was installed in the Potteries and has given satisfactory results. The full answer to the "iron particles" objection, grinding dry and making wet slip, is surely in the fact that several mills are at work in the potteries on various materials and repeat orders have been received. I have had no experience nor presumed to inspect any of the processes of your industry—the practical application of this system of grinding has been left entirely to the practical man who in these several instances has not failed to grasp the advantages—the before-mentioned repeat orders are proof of this.

Mr. B. J. Allen has apparently had some good experience with the Mill—except as to fireclay. We have one Mill giving excellent results in large fireclay goods. They do not grind so fine as has been mentioned in this discussion. Some of our grinding in heavy clay work comes out at only 55% through a 100×100. Mr. Allen need only alter the mesh in the mill to get a coarser material, say all to pass a 10×10.

My answer to Mr. Leese meets Mr. W. Lindley's objection to dry grinding.

I agree with Mr. Bernard Moore that the Griffin Mill may not in all cases be used as a finisher—but that does not depreciate the value of a Griffin Mill as a feeder for the wet pan as suggested in my reply to Mr. Leese.

The Griffin Mills have been largely used in Germany in the potteries for over 20 years. To sum up—apparently the users of Griffin Mills do not dispute my claims, viz:—

Reduced cost of grinding.

Considerable saving of floor space.

A superior raw material resulting in more regular manufacture, consequent reduction in spoilt goods.

The increased quantity of angular particles and corresponding advantage.

The "Disputants" attacked my proposal from a higher standpoint than that to which I aspired. One characterised my claims as "Utopian"; nothing of the sort, I only propose that a considerable improvement will result from the judicious use of Griffin Mills with wet-pan finishing. I do not claim the Griffin process or the "angular" particle to be a panacea for all ills of the industry—simply that an improvement in results may be reasonably looked for—actual practice has proved this to be so. And I hope Mr. Dunn's suggestion, of 1914, that "some Society," of course, distinctly your own, should carry out this research for the general good. Again, allow me to thank one and all for the interesting discussion, and the opportunity of a reply by which I trust I have established my claims.

III.—Unestimated Losses in Pottery Manufacture.

WORKS BLINDNESS.

"Having eyes, ye see not."

DR. J. W. MELLOR.

My contribution to our discussion has to do with psychology. It is very curious how the mind by familiarity loses its sensitiveness to stimuli and becomes passively unconscious of phenomena which otherwise appear very insistent and active. To make my meaning clear, suppose someone removed the head from the statue in front of the station, I wonder how long it would be before the decapitation would be noticed. I do not think that we who pass it a few times a day would detect the loss; we should have to wait for an outsider to notice the missing part. In the same way, things may gradually get wrong on a works, and remain unnoticed by managers and foremen, until a stranger appears who sees the difficulty at once. On his own works, a man is liable to become blind to faults which he would see instantly on the works of another.

To take a particular illustration. A good many years ago I had a letter from an old student who was in charge from the clay to the biscuit on his father's works. He said that he was in trouble with specked ware. I wrote saying that I was going away for a fortnight and recommended him to start with the clay bins, if not earlier, and examine upwards and downwards every possible way dirt or dust could get into the body. I added that if it had not been mastered by the time I returned, I should be glad to come and help. Sure enough, when I returned a letter was waiting for me asking me to go. He pointed out how very particular they were in the clay store room, but there was an iron gas bracket in the very middle of the room. By standing on my toes I was able to bump the bracket with my hat and this was followed by a shower of rusted iron. Part way round the room too was a rusty iron gas pipe which I could see must be gradually shedding particles of rust on to the clay in the bins. He asked me to kick him for not having noticed it before. My belief is that the pipes had been there so long that he was no longer conscious of them. Had he been visiting another's works he would have seen the difficulty instantly; but on his own works he was blind. I have encountered scores of examples since then.

In a lecture I gave at Newcastle-on-Tyne last year I pointed out one or two cases of what I called work's blindness in the

manufacture of firebricks. This idea went the round of the papers, and caused some correspondence; it even appeared in the Children's Magazine. Examples can be quoted from the directive and manufacturing branches of all sorts of industries; from the poorest works laboratory to the most perfectly equipped pure science laboratory.

To summarize, *works' blindness is a kind of disease attended by the blunting of the observational powers due to constant association with a particular works or process.* As a result, a fault may appear in a works where the cause is obvious to everyone excepting to those who know most about it.

RECOVERY OF GOLD RESIDUES.

MR. C. D. GRIMWADE.

The unestimated loss which I propose to consider is the recovery of gold after it has been "lost" by contact with paper, rags, brushes, and other paraphernalia used by decorators, either in applying gold to ware or in cleaning-up. As this is an unestimated loss, in that no one could tell how much gold there was to recover, one should be careful to guard against any looseness in the operation which might prevent the last possible fraction from being redeemed. The method adopted in our own practice is to collect weekly from the decorators' turntables and benches the covering papers which are used, as well as the rags used either for applying the gold to the ware or for wiping the gilders' pencils. Rather than rely upon the decorators to sort out the clean rags from the dirty ones, it is better to collect the whole of the material into a large tank locked up for safety. As regards the tank, it is well to take reasonable precautions against fire, seeing that many of the media employed in applying gold to pottery consist of thin oil, turps, tar and other volatiles.

The recovery of the gold is achieved by burning the refuse and fusing the ash to a clear glass, the only outside expenses being that of the fluxes and crucibles employed. The burning of the rags is not a pleasant job, but with a little supervision it could be deputed to the youngest boy. Before burning, all rags and papers should be carefully opened out and sorted free from stilts and other insoluble objects; if required, these may be washed separately in turpentine, and the oil then burnt with the rags. An iron cauldron twenty inches in diameter, fitted with a stout wire grating of half inch mesh supported six inches from the top, has proved a useful grate. On this sieve rests a light iron cylinder in which the burning takes place. The dust remaining in the cauldron is sieved free from slag and coarse ash and mixed with a flux to which an oxidising agent had been added. A mixture which has proved very suitable in my own practice is: Ash 12 oz., borax glass 10 oz., potassium nitrate (nitre) 2 oz. Borax glass is preferable

to borax crystals in minimising overflow and increasing the possible yield per crucible. Some people have advised covering the mixture with a layer of salt before melting in the oven, but no benefit could be observed from this on trial. The 24oz. mixture above described would nicely fill a three-pint crucible, and might yield anything up to £10 worth of gold in the nugget at the bottom of the crucible.

With the present price of good fireclay crucibles, it is expedient to use a thin earthenware lining inside the crucible, This with the frit drops out *en masse*, and allows the clean crucible to be re-used many times. Firing is done in a slow easy part of the biscuit oven, but of course, the glost oven could be made to serve by increasing the amount of flux used.

WAD CLAY.

Mr. Bernard Moore.

When it was announced that we were to have a symposium on some unestimated losses in pottery manufacture, I tried to think of some small thing that really involved a serious loss to manufacturers generally, and I have come to the conclusion that probably one of the greatest sources of loss on a pottery is the size of the wads that are used. Between what I should call the best practice and the ordinary practice followed in the district, there is an enormous difference. In whatever remarks I may make about wads, I wish it to be understood that I am confining my remarks to general earthenware, tiles or china. I am not dealing with sanitary-ware, which requires a particular sized wad. In the best practice, that is to say, the practice that is followed in those factories where a good deal of attention has been paid to this kind of thing, a wad is not much over 3/10 of an inch in diameter. Now I am quite sure that in fully 50 per cent. of the factories in this district the wads are as much as 7/10 of an inch—approximately the diameter of a sixpence. Now the difference in the amount of wadclay used between using a wad 3/10 of an inch and one 7/10 of an inch, is that the one is more than five times the weight of the other. I am quite sure that there are factories in the district where fully five times as much wadclay is being used as ought to be used. I have seen it within the last few weeks. I am not particularly well versed in the prices of materials such as wadclay, but assuming it is in the region of 25/- per ton, it will be seen that if a manufacturer is using five times as much wadclay for a glost oven as he need do, he is losing a good deal of money unnecessarily. One would not complain about this if one were getting a better result thereby, but I think it is also a fact that, within reasonable limits, the less wadclay that is used the less dirty ware will be the oven yield. There is another aspect of the matter that is worth bearing in mind, and that is, that if you are in the habit of using wads more like the

size of a round ruler than a lead pencil, you are probably getting a saggar per bung less in the oven. When you estimate what that means on a factory with three or four glost ovens firing a week, I think you will not fail to realise that, although on the face of it this looks a small matter, there are factories on which probably a thousand pounds a year might be saved if this "detail" were properly attended to. It is a good example of the "Works Blindness" that Dr. Mellor has alluded to. In dealing with the thickness of a wad it is so easy to go gradually wrong. A man starts alright; he begins with 3/8 or 3/10 of an inch, and within a month or six weeks' time the rolls have got an eighth of an inch bigger. It is not merely the difference between 3/8 of an inch and 4/8 of an inch; it is not as three is to four, but as the square of three is to the square of four. Although your wad may be only an eighth of an inch bigger you may be using twice as much material as you need do.

There is another point. I said to a workman a month or two ago: "How often do you change your die for the making of the wads?" His reply was that he let them run until one hole ran into the other, and then he thought about getting a new one. I seriously think that there are many thousands of pounds a year that are thrown away by inattention to matters of this sort. I have thought that possibly some of the members may be interested in seeing a system which has been adopted for the making of wads at the Research Laboratory at Stoke. By this apparatus square wads are cut of the right size to put on the saggars. It has one great advantage over the wad made in the ordinary wad box, and that is this. When clay is squeezed through a small round hole, as is the case in the making of an ordinary wad, the outside of the wad is much denser than the inside, and it is very much more liable to fly. When the clay is simply cut through, as is the case in the apparatus demonstrated, it has a more even and open texture throughout. I have seen this simple process in use in extremely large factories, in factories much larger than any I know of in this district. It costs very little, and it answers extremely well. You can fix up an apparatus for a few shillings, and by means of it you may make wads rapidly, furnishing them to the placers on boards, and so preventing the undue drying of the wads. If the wads get too dry before they are put on the saggar, naturally they break and fly. By the apparatus I commend to your notice the wads keep in much better condition.

MISCELLANEOUS LOSSES.

Mr. A. Fielding.

Probably one of the chief reasons why there are so many unestimated losses which occur on the various potteries up and down the district is the fact that a man needs to know something about so many subjects if he is to be a successful potter. Let us consider power generating, to begin with. How

many are there of us who understand the question of steam-raising in a really thorough, practical and technical form? We cannot be expected to. We have not had the opportunity of studying these things, and have been taught to look upon other parts of the works as being more important. Some little time ago an inspector of engines and boilers told me that the Potteries district, taken on the whole, was the worst engined and worst boilered district that he had ever come across. That is rather a sweeping assertion, yet when one comes to look at other industries, and see the up-to-date mechanical applicances in operation there, one cannot fail to recognise that the pottery trade has a good deal still to learn in the department of steam-raising. I remember going on to a pottery some years ago and going round the place with the proprietor. On arriving at the sliphouse we found that it was not working. The men were standing around doing nothing, and on being asked the reason, replied that they were waiting for the engine to get steam up, so that they could work the pug. The engine was an 8-in. engine, and the governors were turning round and doing nothing. I suggested to the proprietor that he should go to an engineer and get some advice, which he did, and in less than six months that same engine was driving two 6-ft. blungers, a 6-ft. glaze pan, the sliphouse and the jiggers. It had been speeded up from about 27 revolutions a minute to 140. It could not have taken more than five or six horse power to drive the pug, and could not do that properly before the alteration, whereas afterwards, the engine was found to be capable of 17 horse power. I take this to be a good example of an unestimated loss.

Then let us consider for a moment the question of stoking. Why should a stoker send out black clouds of smoke from the chimney and needlessly waste his employer's money in so doing? To my mind a good stoker is really worth more than a good engineman, because he can save or waste you more money. To put slack on a fire seems a very simple thing, but there is a right way and a wrong way of doing it—an extravagant way and an economical way.

Then there is an economical and an extravagant use of steam with the engine, according to how far we understand it. How many of us think of keeping a monthly card of the engine working, in order to test it, and see if it is working all right? When one reflects how much one has to pay to-day for slack and labour in order to raise steam, it seems an extraordinary waste of money to see exhaust steam blowing out all over the place. There are plenty of potteries where too much steam is generated for the running of the machinery on account of the bad setting of the engine valves. Why could not some of this be utilised in the more distant parts of the works where the exhaust steam cannot get to, in the drying of the clay ware and the heating of the warehouses and workshops?

Then let us consider the question of condensed water from steam pipes. I make bold to say that there are not 50 per cent. of the pottery manufacturers who use this water over again, yet it is the finest water that one could possibly use for the boilers. We would rather use town's water, and pay so much a gallon for it, although it is far more detrimental to the life and efficiency of the boiler. Things like these are what we fail to see because we are so familiar with them. When we estimate what the production cost is of a toilet set, or whatever else it may be that we produce, we fail to take into the calculation that we are using double the steam we need use, using double the engine slack that we actually require, and paying for water that we could get for nothing. Such items as these are truly unestimated losses—losses such as could be prevented with a little careful scrutiny on the part of managers and foremen.

A load of clay comes on the factory. How often does the man who is responsible for the unloading think of cleaning up that part of the floor on which his cart stands? As a result, the clay dropped on the floor may have to be thrown away, because of its contact with dirt.

It is the same with gas lighting. Gas burners are often permitted to roar away through want of just a touch of control. We never think of putting a governor on the supply pipe.

So we might come to the question of window cleaning If you were to walk into some of the workshops it would be difficult to tell whether the windows are of glass or not, and gas is burned as a poor substitute for the daylight which could be utilised for nothing. The same thing applies to the whitewashing of walls. Apart altogether from the hygienic aspect of whitewashing, it pays to keep walls whitewashed from the point of view of reflected light.

Then there is a matter which has never been very seriously tackled in this country, so far as I know, although it has received some attention on the Continent—I refer to the waste heat from the ovens. Sooner or later, however, I feel sure that we shall use all the waste heat possible from the ovens in order to heat up our workshops, warehouses and other parts of the works.

In the placing of biscuit ovens, one can find a tremendous difference in the amount of placing sand that is used in one oven as compared with another. Could not some sort of inducement be offered to oven placers to economise in the use of placing sand? It seems a small detail, but there is no doubt sufficient entailed in it to pay a week's expenses to the seaside.

It is the same with the glost ovens. It is often the custom for stilts and spurs to lie about until one becomes callous to the monetary value of them.

In the matter of machinery lubrication: one occasionally comes across an engineman lubricating bearings with a jug full of

oil, and consequently using four times the amount of oil that he would use if he used a proper oilcan.

The whole of these little things which I have mentioned, which might be added to indefinitely, have a great bearing on the overhead chrges which have to be borne by a factory. Individually, they may not represent much, but in the aggregate they will no doubt make a tremendous difference in the course of a season.

MR. F. MORRALL.

Flint. Attention should be paid to the quality of raw flints. Where it is calcined and ground on the works, iron pyrites and other foreign matters have occasionally been found, having been missed by pickers at the other end. When calcined, see that the small pieces of flint, found in the bottom of the calcining kiln, are properly picked and sieved from the ashes and refuse.

Grinding. Pans should be properly loaded with runners. If charges are not guessed at, but systematically weighed and checked, you will not be surprised at being short of flint before you tried weighing.

Arks. When getting water off arks, you should be very careful. A careless man may waste tons of material in a year through pulling plugs out too low down the ark.

Mixing Sliphouse. If you pay your slip-maker by results, say so much a ton, or in mixing, generally, the slip-maker's chief object is to turn out as much clay as possible. The more clay he makes, the more money he gets, sometimes at the expense of the quality of the clay. For instance: A mixing has just been finished, the slipman has no slip in the finishing ark, and he is anxious that the press man should not stand idle. He may, if he is unscrupulous, start pumping before the body is thoroughly blunged and mixed, and we know with what tragic results many a potter has been ruined, through slip being insufficiently blunged. It is questionable whether piecework slipmaking pays, if you do not have the strictest supervision.

Press Pumps, Taps and Nozzles. The need for careful packing is obvious, and if output is to be maintained in the day, attention to the pumps when ordinary work has ceased is advisable, even if you have to pay extra time for work done. If this is not done, potters may have to cease work, and ovens miss setting in or be delayed on account of pumps going wrong in sliphouse, when attention to them after work had ceased would have obviated this stoppage. The same applies to taps and nozzles. We know they are rather expensive, but to have new ones in stock to replace those which are undergoing repair, is a wise procedure, and will pay for itself over and over again in saving slip.

Pressmen. The loss in slip caused by having fresh pressmen is one that is unestimated. We know to our sorrow, that press

cloths will wear out (and any but the best quality of cloth is indirectly a loss). Very small holes, like pin points, appear. Those working the presses know these holes, and stop them with clay. Fresh pressmen do not, and without the keenest observation on their part, they can only find out by experience and consequential loss of slip. So if you have good pressmen, see to it that for an extra shilling or two, you do not loose them, or yet another unestimated loss will occur.

Sieving. Most of us are familiar with Boulton's patent siever, and here a considerable amount of loss may occur if proper attention and cleanliness is not paid to this type of siever. Instead of knottings being lawned out, we shall have half knotts and half slip, or more than that. The lawns should be swilled out at least twice a day, and should be taken out at least twice a week, and scrubbed with a hard brush. After being scrubbed, the loss that may occur will be palpable to anyone. The first knotts to come through will be quite black, showing that it is knotts only. Gradually, however, as the lawns get blind, slip will come through with the knotts, and eventually over 50% will be slip.

Pugging. Do we have a systematic examination of our pug mills or do we wait until the potter begins to complain, before we have it overhauled? Badly pugged clay means cracked ware, and if we wait until we get badly pugged clay, we shall have some unestimated losses.

Drying Kiln. To those who dry flint, bone and stone, attention should be paid to the flues of the drying kiln. The loss in fuel is very considerable owing to choked up flues. Material may be on the kiln twice as long as it should be owing to this trouble. It is far more economical to have flues cleaned out periodically than wait until material takes a week in which to dry. Again if the kiln bottom is not made hot enough before the material is put on, and if there are any bad joints or cracks in the bottom, material will run through into the flues, with the above result, that you have not only choked up the flues, but also lost good material.

Another very serious loss is that which occurs through receiving on the works, materials for body and glaze, which have an excessive amount of moisture. This subject has been thrashed out repeatedly by Dr. Mellor and Mr. Bernard Moore, so that little need be said here, but I am convinced that potters loose a great amount of money, not only by being short in weight, but the faults entailed in their body mixtures being short in net weight of different materials.

Saggars. The building up of the saggar marl is a very important process, and if careful attention is not paid to it, great unestimated losses are liable to occur. The weathering of marl, the size of grog and quality (glost saggar grog has been used in china biscuit saggars), and the proportion of each material and

the thorough mixing of same, if done properly will have a great influence on the life of the saggar.

Glaze. Have potters given sufficient thought to the building up of their glaze, with regard to the proportion of frit to raw material, that constitutes the glaze? I believe I am right in saying that a glaze which can carry the highest amount of raw material along with the frit in mill mixture, is more economical than one with a high percentage of frit, and low in raw material. Of course we may easily go too far and get in trouble. Most of us are familiar with some glaze recipes used on factories. The glaze goes wrong at some time or another, and all sorts of methods are used to put it right. A little of this glaze and a little of that is added, sometimes with the desired result. When the glaze is weighed out to the mill, it is found that two or more frits are needed. Sometimes, more often than not, the glaze is carrying a great deal more frit in proportion to raw material than it should. The result is that it will not keep in suspension long together. It sets at the bottom of the dipping tubs, and has to be dug out of the arks. Occasionally, a glaze that sets quickly is not so economical as one which does not, nor is it as uniform when it is drawn from the oven. Taking quantity, I think we may say for every 100 gallons of glaze used of the heavily fritted one, 85 gallons of the—I will call it—the well balanced one, will dip the same quantity of ware. This I think is an unestimated loss.

DISCUSSION.

Mr. D. F. W. Bishop, M.A.:—I have compared Mr. Grimwade's figures as regards the proportion of fluxes with our own, and they are practically identical. We cover our material in a crucible always with half an inch of salt. Why this is done I am bound to say I do not know. It is a rule-of-thumb method which has come down to us from the past; it has certainly not been started within the past fifteen years to my own knowledge. On the whole, we have had pretty good success. We use five parts of borax to one of nitre. We sieve this very well first, and also after it has been added to the ash. We line our crucibles with flint; but I confess we are not able to use them more than once or twice. We never put the crucibles in the biscuit oven, but always in the prick of the glost oven fire. We have never lost a crucible yet. The difference in the various nuggets yielded is very great, Sometimes we will get a nugget four inches in diameter and a good half inch or 5/8 of an inch in thickness. Sometimes, on the contrary, the gold occurs in pin points, or in pea formations scattered over the bottom of the crucible with a good deal of flux. I think it depends upon the temperature to which you fire your biscuit whether it is dangerous to utilise the biscuit oven or not. Possibly the earthenware lining to the crucible that Mr. Grimwade has mentioned will do much towards obviating the danger.

Mr. Fielding, in the course of his remarks, made mention of some firms using tail water from stoves in their boilers. I would like to ask whether he has known of a case in recent years where this practice has had to be discontinued owing to the presence of oil in the tail water. I happen to know of a case where a boiler inspector forbade its use on that account. I quite agree that if you can use it there is a good deal of saving, because the tail water is naturally hotter than the tap water.

Mr. A. Fielding:—I have heard that objection raised about the oil being in the water, but I think there are some means of separating it, and so enabling the water to be satisfactorily used. The systems I have seen were in Lancashire. Baileys, of Salford, I think, provide a separator for this purpose.

Mr. J. A. Audley:—There was one remark that Mr. Fielding made with regard to the use of boiler water which reminds me of another consideration which is very applicable to the same thing. The water in this district is comparatively hard. I am speaking now of the public supplies. But there are means by which it can be softened, partially or wholly, and in my opinion it would be very well worth the expense, if it were necessary to provide special applicances—in fact I know it is in practice in one or two places in the district. I am rather surprised that it is not practised much more generally. There are various contrivances on the market for softening water, either partially or wholly as the case may be. One is the common lime and soda purification process, which will answer for most purposes. I understand that this method can be employed in most cases so as to avoid the formation of scale in the boilers. If you can escape the formation of that scale, see what the saving amounts to in a year. You save the trouble caused by scaling, and also effect an economy in heating, seeing that the heat has not to pass through the thickness of the scale which would otherwise have formed. If it is desired to go further, then the Permutite process, which is now being used in many industries, is capable of taking out the whole of the hardness, and making the water absolutely soft. That, of course, would be better still, but this is perhaps not necessary for boiler purposes. It occurs to me, however, that the same considerations apply with even greater force in the case of water that is used for casting, because the small quantities of substances dissolved in the water are very often injurious to the casting slip. Therefore, I cannot help thinking that it would be well worthy of serious consideration to get a special purification plant for the water that is used for that purpose. The original cost would not be by any means overwhelming, and in any case the benefits derived in the course of a year or two would, no doubt, more than pay for the whole of the capital outlay.

Dr. J. W. Mellor:—It is possible for members to see the

Permutite process downstairs. We have it in use, testing it for that particular purpose.

Mr. R. L. JOHNSON:—There are two methods of dealing with the oil. In connection with one of our boilers we have put in a grease separator. Some of the apparatuses on the market for this purpose are very efficient. I think, however, that the more efficient method is to have a tank or well, in which you run all your tail water. This is fitted with an overflow, which must be below the pipe through which the water runs into the tank. Every week end sufficient water can be run into the tank to float off all the oil.

Mr. Audley has mentioned the use of soda along with lime as a means of water purification. I think one wants to be very careful in using soda in a boiler. It is quite true that it is a water softener, but it has a terrible action upon the brasswork. Sodium triphosphate, which will probably do as much softening as soda, will have no appreciable action upon the brasses. If you take a glassful of dirty canal water and put a little of this in, you will find all the sediment go to the bottom very rapidly. It is certainly the best way to take that sediment out before the water is charged to the boiler. That again is a matter of some expense, however. If you do not take out the sediment, it is a good thing every 24 hours or so to blow out. With proper precautions, by reducing the steam to a reasonably safe limit, and watching that the valves are in thorough working order, it is possible to blow out the whole of the sludge whilst working. As has been pointed out, there is probably more opportunity of saving through economy of coal by keeping incrustation from the inside of the boiler than by using up tail water. Not only do you save more in coal but you obviate the danger of burning out your boilers. There is nothing that will so effectually prevent the heat from getting through the boiler plates as the incrustation that is formed inside the boiler.

MR. B. MOORE:—Town water which has been used for washing up calcined bone ash is quite suitable for use in boilers without any addition.

Mr. H. S. NEWMAN:—Arising out of what Mr. Fielding has said, there is another point which has occurred to me in going round various factories, and that is friction losses. The way in which the shafting is lined up very often results in undue friction. Again, power is frequently transmitted from the shaft through bevelled gears, made of wood, or maybe or iron, badly fitted. If some of the raw hide pinions or built up gears of cotton material were used, this might save a good deal in the shape of friction losses. It is open to question whether it would not pay a good deal better to pull out the steam engine altogether, if satisfactory arrangements for providing steam for the drying stoves could be provided, and install individual electric motors. If some of the

bigger manufacturers would look into this matter they would no doubt find they are losing a good deal in this particular detail. There is another point that deserves serious attention, and that is the amount of labour that is entailed through the present unsatisfactory lay-out of factories, and the miles that ware has to be carried from shop to shop in the course of its manufacture, which might be obviated by a slight rearrangement of the shops.

Mr. A. Fielding:—I have gone into the question of power very carefully during the past twelve months, and have taken the advice of the best authorities I could find. I was advised that generally speaking, this sub-division of power was not economical, and that for the potting industry, on account of the exhaust steam that can be used so very effectively for drying and heating there is no power so economical as steam. With proper organization every unit of steam that is generated can be utilised at some point or other of the factory, and it is this which gives the steam engine a decided advantage over a series of separate motors.

Mr. R. L. Johnson:—Before the discussion on the boiler question is closed, I would like to mention an opinion that was expressed some little time ago by certain government experts on boilers in regard to some of the arrangements in the Potteries district. At the time when there was such a great scarcity of fuel in the district we were induced to try to make use of some of the South Wales fuel, and in order to get our boilermen to use this fuel we took the opportunity of asking the government experts to show us how to use it. Whilst they were down here we thought we might be able to get some value out of their experience in regard to boilers. Now whilst Mr. Fielding has cited a case of experts who have come down to this district and given it the worst possible name for its boiler arrangements, there is another side to this matter, and that is that these particular experts stated that some of the boiler paraphernalia in this district was as good as any they had seen in the Kingdom, so that we have two sides, even to this matter. One of the best remembered reasons for waste of fuel that these government experts gave was the carrying of live steam to a point 140 yards away from the boiler, without any covering of any description on the pipes. When the steam got down to the far end it was practically water. The adequate covering of steam pipes is a matter that can make for real saving, just as inadequate covering will make for serious loss.

IV.—Drying Stoves Scientifically Designed.

By B. J. Allen.

PLENTY of literature is available on the subjects of heating and ventilating, but there does not appear to be much published information on the question of combined control of humidity and temperature in connection with potters' drying stoves.

Some months ago when I was considering this problem, the *British Clayworker*, Vol. 28, No. 330, page 153, published an article describing some "American Methods of Manufacture" being "Some impressions of a business trip." This article deals with a brick dryer and describes an apparatus which appealed to me as worthy of consideration. I have prepared a drawing from the diagram which illustrated the article, and will read the two paragraphs dealing with the arrangement:—

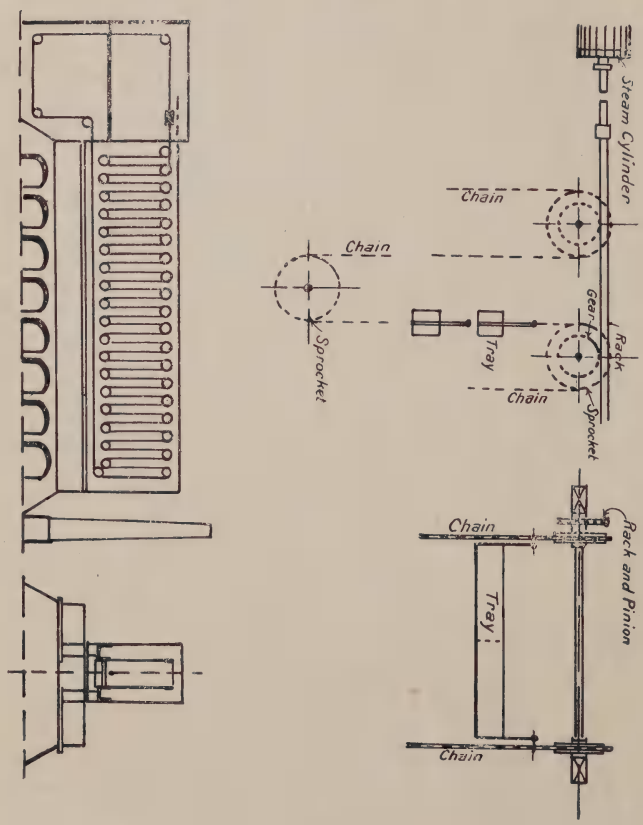


Fig 1.

"The continuous "Hoffman Kiln" has a tunnel immediately "over the centre of the Kiln flue, which is also in the centre, between "the chamber walls. The tunnel obtains its heat by radiation from "the flue, the covering of which is suitable for the object in view. "It also obtains heat by radiation from the chambers in fire, and "exhaust steam can be carried to the tunnel. The system is as "follows:—

"The bricks are placed on end in oblong boxes, with perforated "sides and bottom, about 9 feet long, these boxes being slung "between vertical sprocket chains. The sprockets which carry "the chains are attached to toothed wheels, which in turn are driven "by a long toothed rack, the movement being intermittent and of "such duration as allows the empty box to be filled by the machine "hands, and the full boxes emptied by the setters. The apparatus "contains about 600 boxes each holding approximately 80 hollow "bricks. About 48,000 are made daily. The bricks dry sufficiently "in 24 hours to be set in the kiln.

"The chains pass from the brick machine up to the tunnel on "the "Hoffman" and then up and down vertically from one end to "the other, returning along the bottom of the tunnel, down the "kiln side, to the setters, and back to the machine.

"The only drawback would seem to be in that the bricks are "wheeled from the boxes to the kiln. If the bricks could be con-"veyed direct, to the chambers, the apparatus would then enable "seven men to deal with 48,000 hollow bricks per day from machine "to kiln, for about 3/- per 1,000. Most of the drying being done "by a waste heat."

The drawing is altogether out of proportion, and as you will see presently, some of the most valuable and important features have been overlooked.

I made enquiries about what had been done in this direction in U.S.A., and find that considerable progress has been made and very remarkable results obtained with almost every class of clay ware.

The next illustration shews a diagrammatic vertical mid-sectional view, and cross sectional view of a drying stove for pottery ware, such as the contributor to the *Clayworker* attempted to describe.

The apparatus is enclosed in a casing—1—made of wood or metal with transverse openings. 2 and 3—on opposite sides—may be closed by slides. 4 and 5 are on the outside of the casing, and at the lower edges of the openings, shelves are fixed to receive the ware before and after withdrawal from the Stove. Inside the stove are fixed sprocket wheels 9, 10. All the upper sprocket wheels are arranged to turn on pintles fixed to the side walls of the casing. The lower sprocket wheels are fixed in pairs

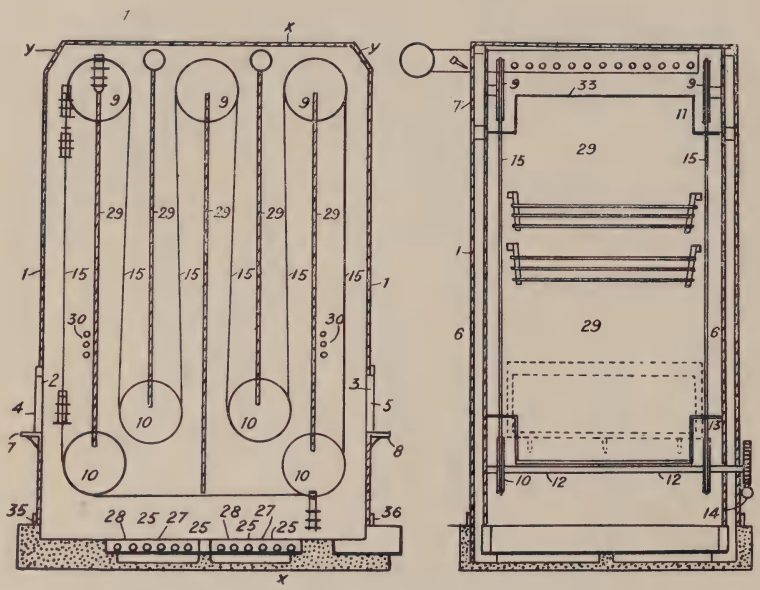


Fig. 2.

on axles journaled in the side walls of the casing. One pair of sprocket wheels next to the side of stove, are fixed on an axle which projects through the casing and carries Worm gear which is actuated by a worm driven by a motor. Two endless sprocket chains embrace all the sprocket wheels, and upon these chains are suspended the ware boards, (in this case they are shewn in groups of three) attached to braces with spindles which connect the links of the sprocket chain, and swingingly support the ware boards. These ware boards are connected with the sprocket chain in as close proximity to each other as will permit of their passing each other, without mutual contact, in passing through the stove. Owing to the manner they are connected to the sprocket chain, the boards are readily passed by the sprocket wheels and as there are no axles at the top there is no obstruction and small sprocket wheels can be used. The boards swing below the lower wheels and just clear the bottom of the stove.

This construction permits a large quantity of ware to pass through a stove of minimum dimensions.

To heat and dry the ware when passing through the stove, radiators of small steam pipes are fixed at the bottom of the stove and to fully utilise the heated air, vertical partitions are introduced which divide the stove into a series of compartments, and induce an approximate equalization of the heat throughout the stove. To aid this object, radiators (30) are placed in the two end compartments to heat the air which enters when the apertures through which the pottery is put in and removed are opened.

To induce and regulate the currents of air, pipes are arranged transversely across the upper parts of the stove and are connected to a fan or ventilating shaft. The pipes have a series of holes in the undersides and are fitted with dampers which may be regulated at will.

Everything is designed to distribute the air and equalize the velocity through each flight with elimination of eddy currents which tend to unequal drying of ware.

I suppose the greatest fault to be found in the usual type of potters' stove, is the stratification of cold and hot air which is experienced.

Underneath the bottom radiators are removable trays to catch the clay dust caused by placing and taking off the Ware. The casing is made with double walls to permit of an air space for insulation. So that the whole apparatus is highly sanitary and healthy, very efficient and exceedingly compact.

The chief points I wish you to keep in mind with regard to this apparatus are:—The small cubic air space to be heated, and consequently the minimum amount of moisture ladened air to be removed, the great capacity of the stove for the space occupied; easy means of regulating the flow of air and temperature of each section of the stove so that the pottery can pass from the atmosphere of the shop to the highest temperature and dryness, progressively, and in conformity with the requirements of the particular class of pottery to be dried, the workman never enters the stove, and the temperature of the workshop need not be in any way affected by the dryer. The apertures for putting in and withdrawing the ware are only just large enough for the purpose, and are at the most convenient height for easy handling. The speed of travel through the stove can be regulated so that no time or space is lost, and back draught into the shop need never occur.

The next illustration shews on Fig. 3 a diagrammatic top view of the stove across the line *y-y* in the previous slide. Fig.4 is an end view of a group of ware boards and a section of the sprocket chain and the arrangement for connecting the ware boards to the chain. Fig. 5 is a slide elevation of the group of boards shewn in Fig. 4.

FIG 3

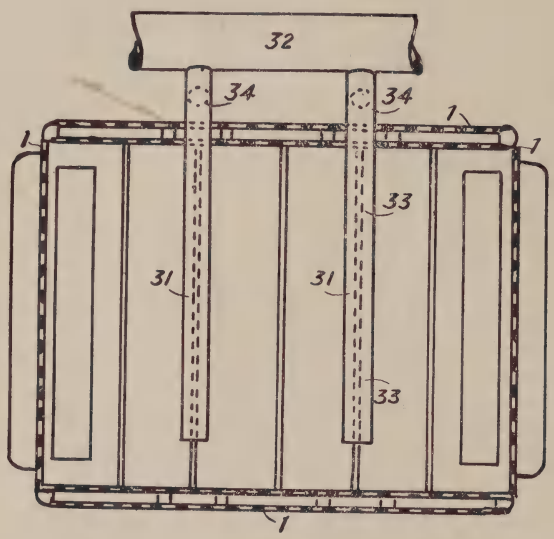


FIG 4

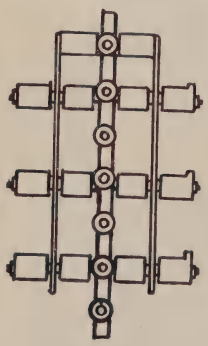
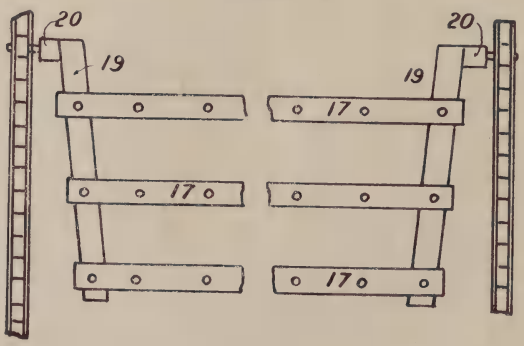


FIG 5



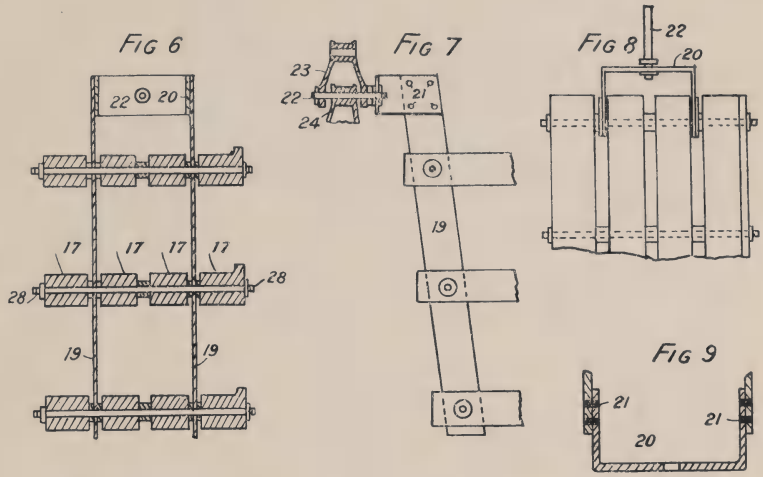


Fig. 6 shews an end elevation of the group of boards shewn by Fig. 4, and the yoke by which they are suspended from the sprocket chain. Fig. 7 is a side elevation of Fig. 6 and shews in detail the connecting link of the sprocket chain.

Fig 8 is a part plan of the ware board and Fig. 9 is a horizontal section of the yoke connecting a group of ware boards with the sprocket chain.

The next illustration shews a working drawing of a stove which has been in use about three years and given excellent results.

The arrangement has been altered since the drawing was made, particularly with regard to the diameter of wheels and the overhanging shaft supporting the top wheels.

The machine shown on the drawing is a standard 120 board machine for general ware, but capable of being at short notice converted to drying insulators up to sizes in cross section 10 × 12in. or 11 × 11-in., and any length up to 5-ft. 5-in. It will be readily understood that as the sectional area of the piece, or the piece in its mould, when the mould has to go into the stove increases so the number of boards decrease.

The standard sizes of this machine are:—

If 12-ft. 3-in. high, then 10-ft. 3-in. long.
,, 9-ft. 6-in. ,, ,, 13-ft. 6-in. ,,
,, 7-ft. 6-in. ,, ,, 16-ft. 9-in. ,,

each stove is 7 feet wide.

These are overall dimensions, but a slight projection occurs at one side where the driving mechanism is fixed up.

The machine is entirely self contained and capable of being set up at any reasonable angle; no foundations or holding down bolts are required, and the apparatus may be regarded as semi-portable.

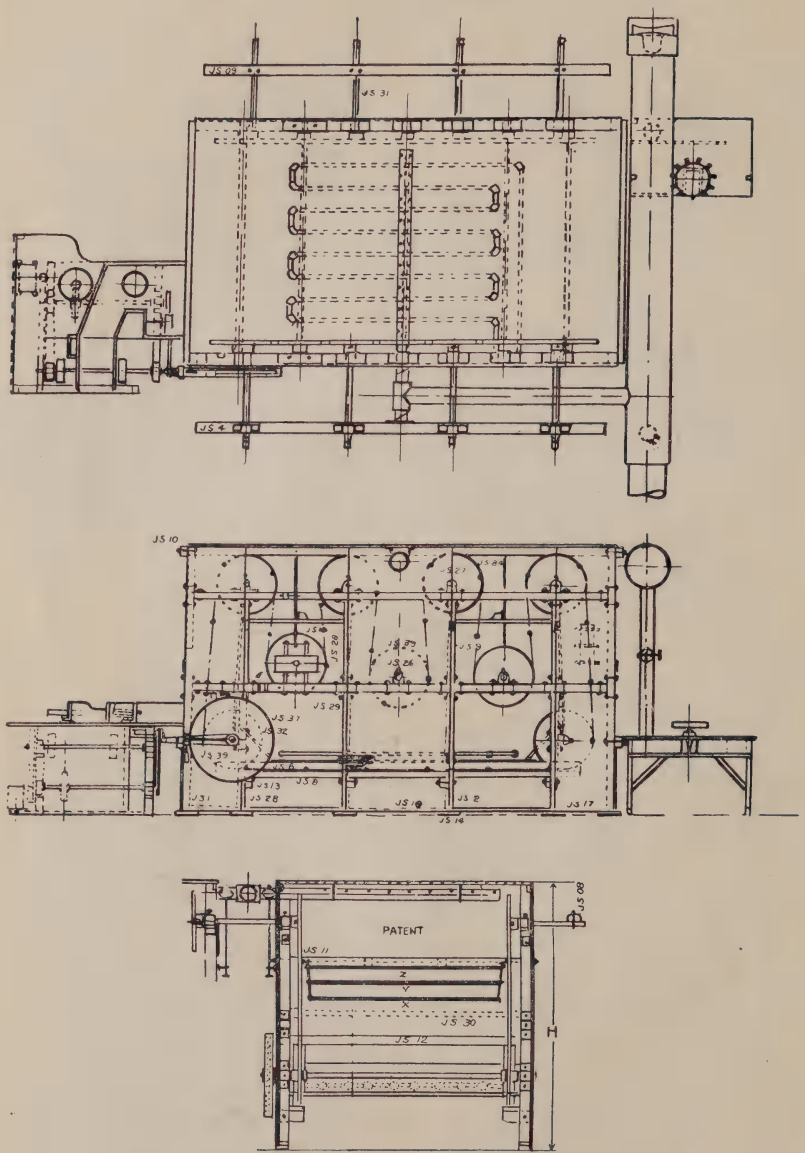


Fig. 10.

This four flight apparatus with 120 boards has proved satisfactory for general ware, and the same arrangement but with 80 boards for a dippers "mangle." Three flight and two flight machines have been used for this purpose where height has been available, and five and six flight machines for low rooms. The 120 board machines are big enough for general hotel ware and for light earthenware or china, smaller machines with 80 or 90 boards are enough.

For the casting shops in a Sanitary Ware Works making Closets and Lavatories, stoves are constructed to hold 18 boards and carry on the average, three pieces to a board. The sprocket wheels being about twice the diameter of those shewn on the last slide.

The height of such a stove is 12 feet (2-ft. or 2-ft. 6-in. of which can be under the floor level) the length is 14-ft. 6-in. and the width 7-ft.

The same machine extended to 28 or 34 feet long, gives a dryer and carrier for large saggars, or with smaller sprocket wheels a dryer and carrier for general ware and tile saggars. For tiles or electrical porcelain still smaller wheels are used.

The next illustration shews a 6 flight machine of similar construction.

Automatic control of the temperature in the stove can be effected by utilising an all metal thermostat which is placed so as to be exposed to the incoming air. This thermostat regulates the steam supply to the heating coil which is of sufficient area to give the maximum temperature required when the air temperature is at the minimum, likely to be experienced. The thermostat is set for the desired temperature with a minimum of steam on the coils. When the temperature of the incoming air falls, the steam is turned on and when the temperature rises, the valve automatically shuts off steam and thus maintains a constant temperature in either summer or winter.

Automatic regulators are available which will give great accuracy in the regulation of humidity and temperature, but each type has its special features, and is particularly suited to a certain class of installation and work to be done.

The importance of adjusting the speed of drying and the temperature in the initial stages cannot be over estimated. Each class of pottery requires different treatment, and where several classes of ware are made in one shop, separate stoves for each class should be employed. For certain classes of heavy pottery the first flights of the dryer, might, with advantage be maintained with a very humid atmosphere, and the temperature of the clay pieces increased without any great amount of drying, then travel forward into a gradually increasing temperature and dryness.

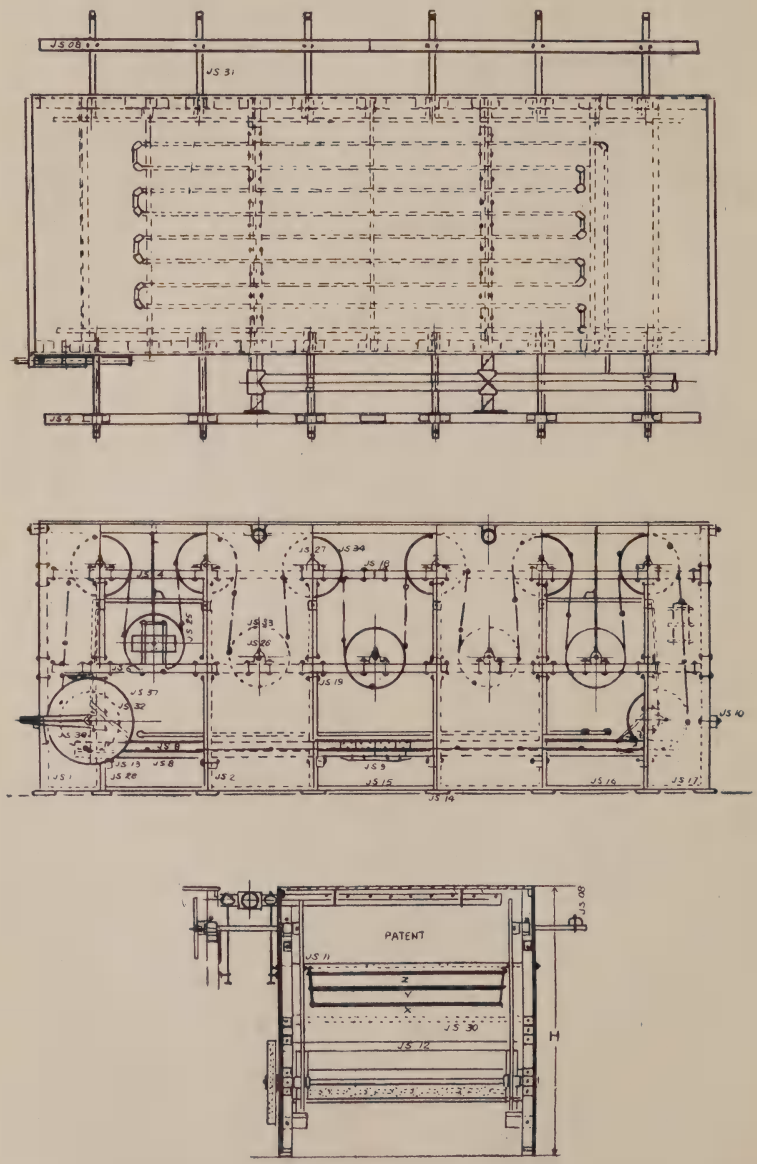


Fig. 11.

To quickly dry thick pottery such as furnace blocks, baths and large electrical insulators. If unequal shrinkage, with twisting and cracking is to be avoided; it is essential that the humidity of the stove in the early stage should be very high. It is better to raise the temperature of the piece to approximately that of the stove before any drying takes place. Then you can decrease the humidity and increase the temperature so as to dry the ware rapidly, with perfect safety. You can heat a clay body to a high temperature in a high humidity atmosphere with safety whilst the same temperature and a dry atmosphere would be fatal.

It will be found in practice that clay pieces having a big water content, can be safely dried quicker than similar pieces of dryer material. I have known big pieces of fireclay sanitary ware, which had not been dried at all, be put into the kiln and come out quite good. This was done to demonstrate that certain losses were not due to ware going into the kiln before being properly dried. The result, of course, only demonstrated that a wet piece can be fired satisfactorily providing it goes in the kiln wet enough.

In 1912/13, the Trenton Potteries Company, installed a dryer for heavy sanitary ware with humidity control. The arrangement they used was a chamber stove and for the initial stages the incoming air was practically saturated with moisture by being drawn through a spray chamber, by means of a fan. Starting with this high humidity atmosphere, the temperature was gradually raised and the moisture content decreased until an absolutely dry, hot atmosphere was obtained. The result was, that they were able to cut down the time of drying baths by one half.

The President of the T.P. Co., spoke very highly of this arrangement, and said it did everything claimed for it. There is no doubt about the principle being right, but the application left much to be desired. The great weakness is the intermittant working of the chamber and the need for supervision.

The stoves of which I have shown you diagrams, permit the application of humidity control to any desired extent. The first flights can be hot and the air almost saturated with moisture, the next flights contain air with a definite percentage of moisture and so on till an absolutely dry atmosphere exists.

It would pay the Manufacturers of this district to have exhaustive tests made—say in this Pottery Laboratory—to prove the minimum time in which various classes of pottery can be dried and the best conditions of humidity and temperature for the purpose. Drying curves for each class of manufacture could be plotted and the ideal stove to carry out these requirements, provided.

Drying curves have been drawn for all classes of American pottery, and stoves designed to suit each class. The machines described are unique, inasmuch that the theoretical ideal can be approximated in commercial practice.

These dryers will, I am sure, dry many articles safely and better in one hour than used to ordinarily take several hours up to a day, and other things, in a day, that used to take a week, and in all cases with reduction in loss due to drying.

It is claimed for this apparatus that drying losses are entirely eliminated, and if a piece comes through in a defective state, it can positively be attributed to some defect other then drying.

I am only attempting to deal with the fringe of the subject in this paper, but I hope that the diagrams and descriptions will serve a useful purpose. The essentials of successful drying are:—first, you must have the humidity conditions right, the air supply at the proper temperature and in sufficient volume to carry the moisture; and finally, the air must be evenly distributed in a manner to effectively dry all parts of the ware gradually and uniformly. No fixed rules can be given which will be applicable to all pottery. The rate of travel through the stove, the temperature of the various flights, and the volume of air passed through the ventilators, will vary for every type of pottery, but the diagrams will serve to shew how to obtain conditions of drying to meet any and every requirement with the greatest economy in fuel and labour. It will readily be seen that for thick pieces such as fireclay baths, gas retorts, etc., requiring a high degree of humidity at the beginning of the drying which should be gradually reduced, allowing the pieces to dry evenly, uniformly and without cracks, this type of stove is ideal. Immediately the piece is finished and hard enough to stand up on a shord, it can be put in the stove and need not be touched again till it automatically reaches the glaze shop. The right conditions and time of drying having once been established for any particular class of pottery, the stove is arranged to meet these requirements and perfect conditions of drying are ensured at all periods of the year, and under all atmospheric conditions. The construction of the stove permits goods to be made on one floor and delivered on another either above or below.

Apply the apparatus to saggar drying. Every saggar as soon as made, goes into the stove and is not seen again till it reaches the saggar-house at the oven ready for use.

Two such stoves are in use in a tile works in the States, each constructed to hold 600 saggars 18×12×9-in. Each stove is 36 feet long, has ten flights; the end flight being a drop down of 15 feet into a lower floor which is the saggar making shop. The flights on the upper floor, are 11-ft. 6-in. high and 7-ft. 6-in. wide. At the tenth flight, the saggars are taken off dry for storage or fixing in the ovens.

These two drying stoves will keep going, two saggar-making machines, each making 500 saggars per day, and three hand saggar-makers.

The feed is through two apertures in the end flight, one on each side.

The advantages of the stove for electrical porcelain must be very great if only to relieve the shops not to speak of the quicker and safer drying. The same remarks apply to a Sanitary Earthenware Factory. In fact there is no branch of the clay industry where the stove is not an economical necessity.

Firebricks, and other bricks made by hand or machine can be produced in bulk having a small shed at the end of a Staffordshire kiln, and carrying the dryer over the kiln as mentioned in the first part of the paper. The saving of floor space, fuel for drying, and labour, would represent a handsome profit.

In these days of heavy labour costs, this subject of drying, for the clay industries, is very important. Human labour must be less taxed than in the past, and to replace this supply of energy, a more efficient producing method in every industry will have to be adopted; in the Clay industry, the losses in output due to bad methods of production, is possibly as great as the loss in output due to shortage of labour.

We must have more and better products with less percentage of loss in manufacture, if we are to be compensated for high wages.

Entirely eliminating losses due to drying may appear to be a rash claim, but I think it is quite possible. If you can dry some pieces satisfactorily, it would appear only necessary to provide the same conditions to get all good. The apparatus described certainly gives you the opportunity of passing every piece through the same conditions of humidity and temperature, and I think is as near fool proof as human ingenuity can make it. The conservation of heat and space combined with efficiency and perfect control, should make this apparatus worth serious consideration.

DISCUSSION.

MR. B. J. MOORE:—Has Mr. Allen any figures to submit with regard to the cost of this apparatus?

MR. B. J. ALLEN:—In November last year I arranged for one of these 120-board stoves for general ware to be constructed over in the States, and sent over complete in all details. The cost was then 1750 dollars, F.O.R. Trenton, N.J. I do not know what it would be to-day; the terms are "Prices Ruling at date of dispatch."

MR. F. J. GROCOTT:—I would like to ask Mr. Allen if he could tell us anything with regard to the speed of the in-coming air, because this has naturally a good deal to do with the drying of all stoves?

MR. B. J. ALLEN:—The speed of the in-coming air is absolutely under control.

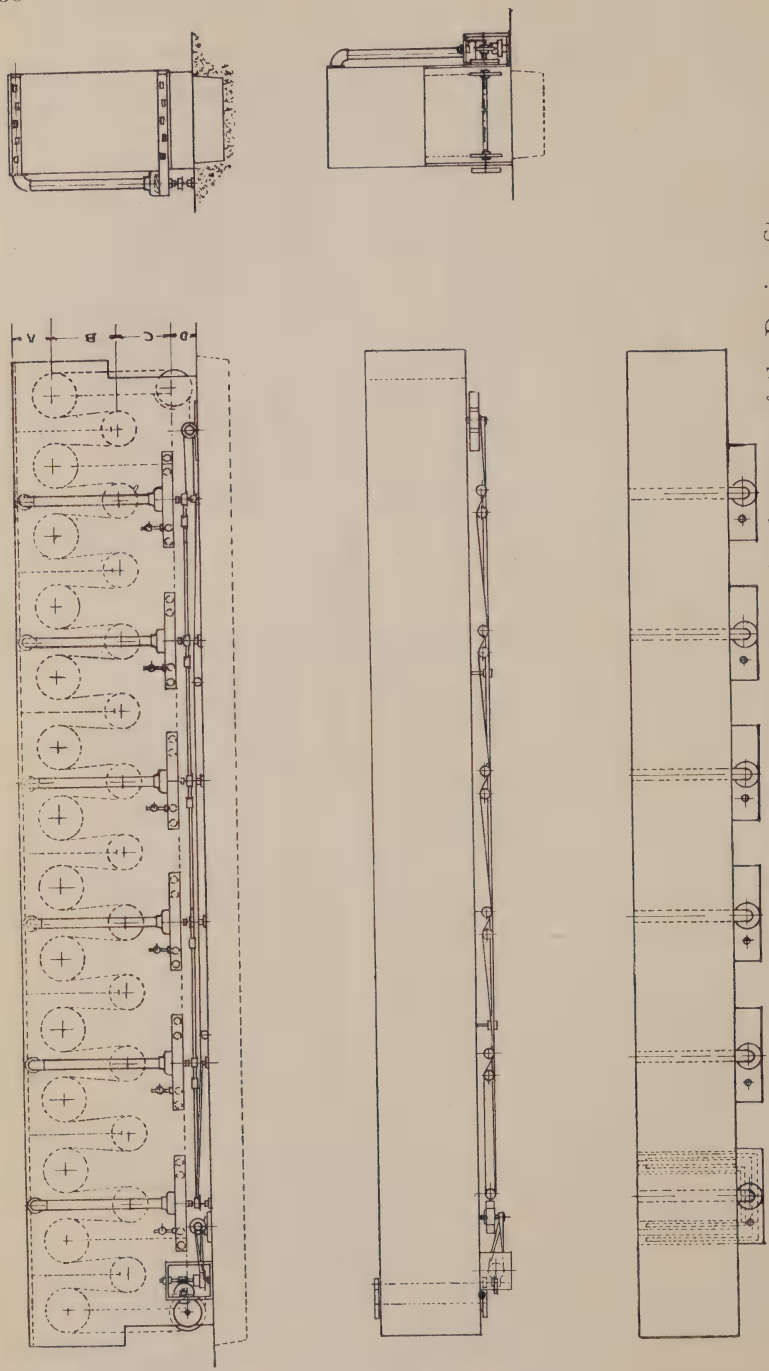


Fig. 12. Diagrammatic Representation of latest development of the Drying Stove.

Mr. F. J. Grocott:—As a stove builder, I know that this has a great deal to do with efficiency. In the old potters' stoves the difficulty was mainly due to the stagnation of the air, moisture being given off from one article to another. On the other hand, if you have a velocity that is too speedy you are likely to meet with cracking; but if you get just the right speed of air—the crawling speed, just on the move—you get the ideal results. With sand core drying it is just the same. If you travel through any faster than a crawl you produce cracking.

Mr. B. J. Allen:—Mr. Grocott is quite right in the point he raises. In the initial stages of the drying you want an absolutely humid atmosphere, in other words, a stagnant atmosphere. If you put a sand core into a comparatively moist atmosphere and raise the temperature in the early stages without any appreciable drying, it is possible to dry without the core cracking, whereas if you put a green sand core into a hot oven you can depend upon it you will get a waste core. The same principle is, I think, applicable to pottery.

Mr. F. J. Grocott:—But what is the velocity?

Mr. B. J. Allen:—I could not tell you that because it would vary with every stove.

Mr. F. J. Grocott:—That is just what I was trying to get at—to see how far the speed of the air affects the efficiency of the stove. I find it has a good deal to do with the drying of sand cores.

Mr. B. J. Allen:—I should not think the speed of the travelling of the air has anything to do with it. If you were to exhaust the moisture without removing the air, you would have no need for any further in-coming air. The velocity of the air passing through the stove is a matter that is controlled by the degree of humidity required in each particular section, which in turn will be regulated by the amount of ventilation of each particular flight, and as the ventilating pipes with their perforations are each controlled by a damper, you control the velocity of the air travelling through each particular flight, regulating the humidity of that particular division by the same means.

Mr. A. Bailey:—Do I understand that the stove is fed at one side and emptied at the other?

Mr. B. J. Allen:—Yes. In the ordinary stove the ware is fed in at one side and taken off at the other.

Mr. A. Bailey:—What I have in mind is a platemaker's stove, which seems to raise a difficulty. A platemaker usually works with one attendant, and if the ware is put in at the one side

and taken off at the other, while the attendant was at the back side of the stove taking off, the platemaker would be either running his own moulds or standing still, which would be a distinct disadvantage. I would also like to know if the boards are put in full of moulds containing the ware, because if so I am afraid the weight question would largely interfere with the popularity of the apparatus. Mould runners are not allowed of course to carry weights exceeding a certain number of pounds.

Mr. B. J. Allen:—I do not know much about platemaking, or the general domestic pottery trade, but I cannot see that the points mentioned raise any serious dicffiulty. If you prefer to put on and take off at the same point, you merely allow the boards to travel through the stove and return. With regard to the ware, I do not think the difficulty raised is unsurmountable; smaller boards can be used to place on the permanent trays, two or three moulds being put on each deck.

A Member:—What advantages does this apparatus offer as against a vertical mangle? It seems to be a complicated apparatus in comparison with the vertical dryer.

Mr. B. J. Allen:—In a vertical apparatus you have one flight only. The apparatus I have described is an extension of the principle of the vertical mangle. If you get any advantages from a vertical mangle, you must have greater advantages by repeating the towers and controlling the humidity of each flight. You have no means of controlling a vertical mangle. You do not know what is happening at any portion of it. You may be having a frightful heat at the top and not enough at the bottom. It is not easily controlled, and you have no means of telling what degree of humidity you are getting. Then, too, the size of the stove described is considerably less than a vertical. In an ordinary vertical mangle you cannot control the humidity of any particular portion of the stove, and that is the point that I am trying to emphasize—a stove correctly designed should permit you to control the humidity of the atmosphere in various stages of the drying, starting with a high humidity, and gradually progressing to a totally dry atmosphere. If that can be produced in the present vertical mangle, there is no necessity for changing, but I do not think it can.

Mr. D. F. W. Bishop, M.A.:—I take it from Mr. Allen's remarks that it would be better to leave the boards on the stove and in the general trade to put the moulds on to the boards. I should like to know if Mr. Allen has any figures with regard to losses due to movement.

MR. B. J. ALLEN:—It was my intention to present you with a lot of figures, but I thought it would be too much to inflict upon you in one paper. You can have these in detail later if you wish, or the figures might appear in the *Transactions*. I would like to emphasise that the apparatus is not an untried thing. Quite a few of them are now in use and definite data are available. The inventor is Richard Wainford, a man who lived in the Potteries for quite a long time. He is entirely responsible for it: I am only responsible for the remarks made as to its probable application.

MR. B. J. MOORE:—Has Mr. Allen any figures amongst his statistics as to the capacity of the stove in terms of 10-in. plates for a given area occupied by the stove? That is rather an important point in fitting up old shops where the stove accommodation is limited.

MR. B. J. ALLEN:—Yes. Statistics on that point are available, for hotel chinaware, which I presume would meet the case.

MR. B. J. MOORE:—Can Mr. Allen give us an address where such information is available?

MR. B. J. ALLEN:—I can myself let you have all particulars. The manufacturers of the stove are The Wainford-Darling Co., of Trenton, New Jersey. All the statistics they have and the details have been sent on to me, and the idea was to construct these stoves in the Potteries after we had received a complete stove as used in the States and proved it to be satisfactory. This was considered to be a quicker means of making the thing known. The stove is still on the way.

MR. C. D. GRIMWADE:—Can the apparatus be so constructed as to turn corners, and to what extent can it be made a boxed-in transporter on a works?

MR. B. J. ALLEN:—I do not see any difficulty at all in using it as a transporter. You can start the apparatus going at one end of the works, and you can take it off at the other without difficulty, except on the score of expense. You would need a greater number of boards, a longer chain and consequently greater motive power to drive the apparatus. As regards turning corners in an horizontal plane, I think there would be some difficulty. It is an engineering problem requiring consideration.

V.—Some New Appliances in Potting.

By A. S. W. Odelberg.

It is with the deepest feeling that I once more stand amongst you before this Society. Although it is only a little over five years since I parted from you in Paris at the end of a most enjoyable and interesting tour in "la belle France," it seems to me that centuries have passed owing to the terrific calamity which has shaken the whole civilized world in its very foundations. You can understand how pleased I therefore was when I received your Secretary's kind letter of invitation, asking me again to give a short address to you upon our common subject, Potting—so old and yet so new—in which there is always something fresh to be found. I feel this to be a token of better days ahead, of stronger international understandings, and my thoughts involuntarily turn to your great author and lover of mankind—he that let Scrooge's nephew characterise Xmas as "a good time, the only time I know of in the long calendar year when men and women seem by one consent to open their shut up hearts freely and to think of people as if they really were fellow-passengers to the grave and not another race of creatures bound on other journeys." Something here tells me that this good tradition amongst you is not extinct in spite of all hatreds which these dreadful last years were bound to create, and I also feel that above all this exist scientific ideals which join us in international brotherhood.

Your Secretary, Dr. Mellor, has offered my country the honour of a visit promised for the year 1922, so let me now take the opportunity to wish you one and all a hearty welcome, to our northern shores, where I shall be proud to give my time and service in showing you the different spots of interest and importance in my beautiful country, and of course not forgetting our mutual subject, Potting. And now with the help of slides taken by myself I will endeavour to explain with your kind patience these few new ideas of mine.

Electric Railways for Drawing Ovens, etc.

For many years past there have always been difficulties in recruiting labour for the ovens, and especially since they have grown to the great size now in vogue. To substitute some of the manual power has always been our great aim. Several projects were discussed and finally we came to the decision to build a kind of electric railway, or rather "carrier" system.

Especially in the drawing of ovens this arrangement has made quite a revolution. The saggars filled with fired ware "wander" quite independently from the oven to the warehouse where they

are emptied whilst in movement by the sorter, without it being necessary to remove the saggars from the carrier. The saggars when empty return to the placing room near the oven, where they are taken from the carriers at the most convenient spot. In this manner the goods are handled once only from the oven to the warehouse, and the manual carrying of goods and saggars is largely eliminated.

In the first instance we installed this arrangement for the Biscuit ovens only, but the result was so good that we introduced another for the glost and a third one to take the goods from the glost warehouse through the other warehouses to the packing shed. You may get an idea as to the saving of labour when I say that we only require about 50% of the labour formerly employed, and also save about two hours time, and have much less breakage.

A few years ago we introduced Schöne's Elutriation Apparatus to test the fineness of our ground materials. It is a well-known fact that in this manner one may obtain the surest knowledge on this subject, and that very important conclusions may be drawn from it concerning milling and mill materials. This apparatus is also used to analyze clays, and we find that the results correspond very closely to those obtained by the chemical rational analysis.

The following figures may be of interest: "A" represents the percentage of elutriated material when the velocity of the current of water equals 0·025 cm per sec.

	Fayles' Blue Clay.	B.C. substitute M.	Ditto F.
A.	93·15%	82·1	81·6
The rattonal analysis shows:			
Clay substance	93·02	83·44	85·45
Felspar	0	0	0
Quartz	6·98	16·56	14·55

Quartz Analysis:

A.	$V=0·025$ cm per sec.	55% × 33·67	1850
B.	$V=0·087$	21% × 9·62	204
C.	$V=0·162$	13·8 × 5·18	72
D.	$V=0·46$	3·2 × 0·91	2·8
		Surface factor ..	2128·8

Felspar Analysis:

Surface Factor .. 2949

English Slop Flint:

A.	44%
B.	21%
C.	14·3
D.	10%

Surface Factor .. 1771

All these analyses are rather complicated, necessitating a chemist trained to laboratory work of this nature, and it takes rather a long time to weigh and dry the different trials. In order to eliminate this complication we have constructed an apparatus of a much simpler kind. It is a copper vessel of cylindrical shape and with a diameter of 18·5 cm. The neck (a) at the bottom of the vessel is connected with a tap belonging to the ordinary water supply. The copper vessel is filled with water which can be run off through another tube (b) connected with a Schöne Piezometer or pressure gauge. To examine the mill stuff, flint or quartz for instance, take one pint of the slop at 25 ozs. to the pint, which is poured into the vessel filled with water through the neck (a) by a funnel. The latter is taken away, the neck is again connected with the tap from the water supply, and the latter is carefully opened so that the water current in the vesssl at the widest part (diameter 18·5 cm) has a velocity of 0·025 cm. The velocity can be controlled by a watch and measure glass and also by the pressure gauge.

After the water has run with this velocity a few hours it is quite clear. What remains of the mill stuff in the copper vessel is taken up in a pint measure which is filled with water to the brim The pint weight of this is taken, and hence the dry contents can be calculated by the usual formula, and expressed in a percentage of the original material. The weight of this is 20 ozs. plus 55 grams. Let a be the dry contents of a pint of slip before the elutriation, a_1 the same after elutriation, and L the specific gravity of the dry substance.

$$25 = a + 20 - \frac{a}{L}$$

$$a = \frac{L \times 142}{L - 1} \qquad (5 \text{ ozs.} = 142 \text{ grams})$$

$$a_1 = \frac{L \times 55}{L - 1}$$

To calculate the percentage quantity elutriated at a velocity of 0.025 cm per sec. which we will term A:

$$A = \frac{100\ (a - a_1)}{a} \qquad \text{or in this case}$$

$$\frac{100\ (142 - 55)}{142}$$

$$A = 61\%$$

It is evident that what is left of coarser material in the copper vessel can also be analysed by using greater velocities of the current of water, in the same way as with the Schöne apparatus, or

by the use of vessels of different sectional area.

A.	$V=0{\cdot}025$ cm per sec. diam. of vessel	18·8 cm
B.	$V=0{\cdot}087$	9·9
C.	$V=0{\cdot}162$	7·2
D.	$V=0{\cdot}46$	4·3

The mill stuff is introduced first into the vessel of smallest diameter and—after elutriation—into those of larger diameters in series.

As we have found with Schöne's apparatus, it is as a rule only necessary to determine *A* or the amount which has left the vessel at a velocity of 0·025. Knowing *A*, one can form a very good opinion of the composition of clays and also of the fineness of the mill stuff. This method constitutes a wonderfully good control of the milling and an excellent guide as to the running speed required to furnish the best results, the proper time for milling the charge, and what best suits the various bodies.

Jolleying Square Dishes.

For some considerable time I have had it in my mind that it would be of great advantage to the potter to be able to make square dishes by the jolley. Of course, there have already been certain methods of accomplishing this, but as far as my knowledge extends they had the disadvantage of being dependent upon a moving jolley which is very tiresome to the operator, besides having other defects. We solved this difficulty in the first instance by a kind of compromise, that is to say, by keeping the jolly rigid, but allowing the profile to move. On the jigger head of an ordinary oval dish machine is a groove in which the heel of the profile fits. A lever frees the profile so that it can slide in the groove of the jolley arm, a powerful spring keeping it in its proper position so that it follows the groove in the head which runs parallel to the shape of the dish.

This being only a compromise as mentioned above, we did not remain content. After many experiments we hit upon the right idea, that is to say a perfectly rigid jolley with all the necessary movement in the jigger head. This was effected by means of a guide plate fixed on the bench. In this guide plate is a groove in which a stud projecting from the jigger head runs dead true. The groove is of very peculiar shape, and has to be determined empirically by reversing the process. The shape you want is first modelled, is then placed on the jigger head, fitting exactly to the profile of the rigid jolley. Instead of the stud in this case a pencil or needle is fixed to the jigger head, and made to trace the path of the groove on a plaster bat fixed on the bench, simply by turning the jigger head, so that the mould runs true to the profile. The cast iron guide is then modelled from the plaster bat. In this

manner a series of guide plates is made according to the size and shape of the dishes. Exchanging the guide plates, the profiles and the ring in the jigger head when the machine is in active service, is a very simple matter and only takes a few minutes of the operator's time. We have found that a man with this machine will make as many articles as with the ordinary oval jigger and jolley, including both flat and holloware.

Plate Making Machinery.

This is constructed according to the latest English pattern with cast iron frames so as to get as much rigidity as possible. The jolley is provided with loose profiles adjustable in the usual manner by means of a nut. The batting machine has a separate frame so as to prevent any jarring in the plate making machine. It is semi-automatical, that is to say, the moment the profile is pressed down the jigger head begins to revolve, and is stopped by a powerful brake when the profile is raised again. We have found this system better than the automatic system which easily gets out of order and gives uneven bats. The machines and bench are placed at a right angle to the drying stove at the corner of the stove door. This facilitates the work of the attendant who from the batting machine is able to reach the dobbin without leaving his place. The plate making and the batting machines are driven by separate motors fixed vertically which makes the belting so much easier. The drying stove has brick walls in order to retain the heat in the stove and keep the workroom cool. The dobbins have 7 angles, which is the best arrangement for plate making. The plate maker turns out about 1,300 plates per day of 8½ hours.

INSULATORS are also made by a jigger and jolley instead of by a "monkey." By lengthening the jolley arm and fixing it in an inclined position it is possible to make the profile lift vertically and deliver easily. These machines also have a cast iron frame, and are placed at a right angle to the drying stove.

When the insulators are turned and thoroughly dry, a groove must be made at the top for the wire. This is too deep to be made on the machine. Formerly we used a saw and fettled with a knife, but this was slow work, and quickly wore out the steel instruments. The work is now accomplished by means of a felt wheel acting like a circular saw and running at 4000 revolutions per minute. It is partially enclosed in a casing connected with a fan. The groove of the insulator is made in a few seconds, and much labour is saved.

The CUP AND MUG HANDLES are formed in steel dies heated by an electrical "resistance" fixed inside. At first we used Platinum wire, but in 1914 we introduced Nichrome wire, which lasts much longer and is only a fraction of the cost of the Platinum. The top die is kept somewhat hotter than the bottom one which facilitates delivery. In this process no oil is needed to make the clay deliver readily from the steel die, and after cooling, the handles

are ready to be fixed to the cups. We have also constructed motor-driven machines similar to the stilt-making machine, but the machine described above is much simpler and better for the purpose, especially as there are so many different sort of handles. This process is much quicker and cheaper than the old method of pressing in plaster moulds.

In connection with the firing of the boilers and the biscuit and glost ovens we have introduced what is termed the MONO apparatus. This automatically analyzes and indicates on a sheet of paper the amount of carbon dioxide in the gases after they have left the boilers and the ovens. It is of great assistance in securing the economical stoking of the boiler, and is also an excellent control in the prevention of smoked ware in the Biscuit oven, and in securing an oxidising flame in the most economical manner.

Another very good control for firing is the AUTOMATIC Draught Gauge, which indicates the intensity of the draught on a sheet of paper. As it is locked it cannot be tampered with, and therefore gives a true indication of the draught during the whole course of the firing. It is of great value in the case of firing of our ovens which are entirely downdraught, as they are closed during the firing at the arch and the heat is taken out at the bottom (sole) and carried to a high chimney stack.

In 1911 we constructed a three colour printing machine for engraved copper rollers. The three rollers are of exactly the same diameter, and the length of the printing paper between each two rollers corresponds with the circumference of the rollers. Each roller can be turned and adjusted on its shaft by loosening a nut at the conical end of the shaft where the cog wheel driving the roller is fixed, so that a very sharp adjustment is possible. As is always the case a trifle of one colour is mixed with the one following, but this is avoided as much as possible by making the first and second colouring as local as the pattern will allow, and leaving the tracing and the greater part of the colouring until the final colour is applied by the last roller. Generally speaking, we have found that it is best to begin with a yellow colour, the second being pink and the last, blue, Canton, or dark green. The last named colours are not damaged by an admixture of yellow or pink.

Heating Channels from the Ovens.

In consequence of the scarcity and high price of fuel, we were compelled to do everything in our power to economize, and our thoughts turned to the utilization of the heat from the ovens when cooling. This "cooling heat" is in most cases completely lost. An experiment was carried out in the following manner. After the firing had finished an iron pipe was inserted into one of the trial holes of a biscuit oven. At the other end of the pipe an

electric fan was placed, and after shutting the top dampers of the oven the fan was started. It turned out that after two to three days the temperature of the air in the oven was still 100°C. A very good source of heat was therefore at hand, and we determined to carry the experiment further. This time we selected a glost oven to heat the drying mangle which consumes about 15% of the steam generated by the boilers. A flue (about half a metre square) was built up by bricks from two ovens. The outlet from this oven was just over the arch. An extra damper was placed at the top of the cooling cone, and an extra flue provided with a damper was made to connect with the outside air.

A Blackman's fan (70 cm diameter) was used and was driven by motor. After the oven had cooled a little, both the top cone damper and the main flue (bottom) damper were closed, and the motor was started. In order that the air should not be so hot as to cause a break-down of the fan, the bending of the shaft or spoiling the bearings the damper of the cold-air flue was opened in order to bring about a partial cooling. In this way the fan maintained for several days a steady current of air at about 300°C. flowing through the mangle, and this is quite an efficient substitute for the steam.

The following figures will show the economy effected. The fan consumes daily 30 to 40 units corresponding to 40 kg. of coal. The boilers consume 4500 kg. Coal, 15% of which amounts to 670 kg. Coal, and this is the quantity of coal equivalent to the steam formerly consumed in the mangle. It is therefore clear that at the expense of 40 kg. coal we get heat corresponding to 670 kg. coal. It should also be borne in mind that with the hot air current a temperature of 90°C. is obtained in the mangle, whereas heating by steam gives a temperature of 60°C. only.

In the same way we have utilised the heat from the enamel kilns to warm rooms in cold weather, and have found this a great advantage.

Premium System of Paying Wages.

In order to obtain the greatest possible output from our plant, we have introduced almost throughout the whole works a premium system of payment for increased production. Our system is as follows: Taking a platemaker as an example: we know from our statistics the average daily output and we pay him the normal rate on say 75% of the average output. On the remaining 25% he gets 50% more. Should he exceed that we give him 100% on the surplus. Our experience is that this system pays both parties. It enables us to make the fullest possible use of our plant, and produces contented and efficient workmen.

Before parting just a few words. Last time I had the pleasure to address you I finished by showing what a wonderful lever

mechanical progress is in lifting humanity to a higher level. By its production it will in due time bring forth enough material wealth to be in everybody's reach, that is to say, it will stamp out poverty so that all may benefit. No doubt these last years have worked quite the opposite way as three quarters of the world have been trying to spoil what generations have built up. But my dream will still come true, as I am sure that this dreadful bloodshed has not been in vain, and that the time is coming when we will reap the benefit. With the help of science as well, which in every possible way stimulates production, we shall soon, in spite of the necessary aftermath of the great struggle, recover lost ground. I am also old fashioned enough in these times of Armageddon and anarchy to believe that the words from Ecclesiastes—"to every artificer and workmaster" (which also includes the Potter)—have not yet lost their significance: "They will maintain the fabric of the world and in the handiwork of their craft is their prayer."

Fig. 1. Fig. 2. Fig. 3.

MAKING ROOFTILES IN "HEATED" DISCS.

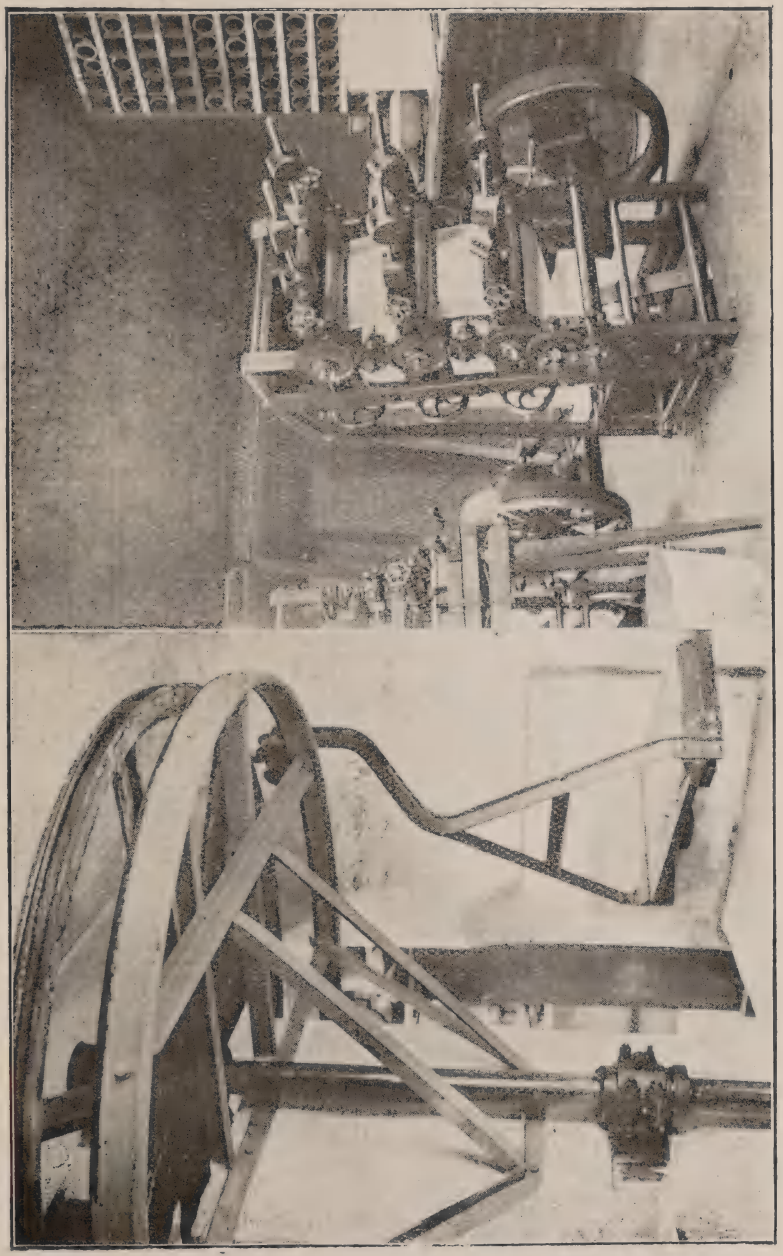
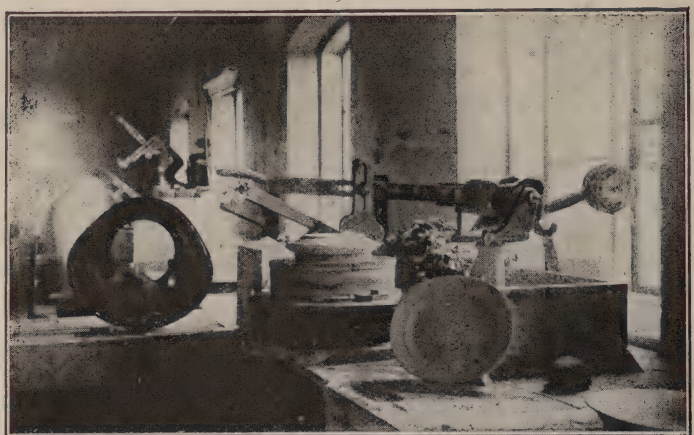


Fig. 4. ELECTRIC CARRIER.

Fig. 5. PRINTING MACHINE.



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Figs. 6 & 7. "Square" Dishes Machine. Fig. 8. Elutriation Apparatus.

Fig. 9. "GROOVING" INSULATORS. Fig. 10. PLATE MAKING. Fig. 11. INSULATOR MAKING.

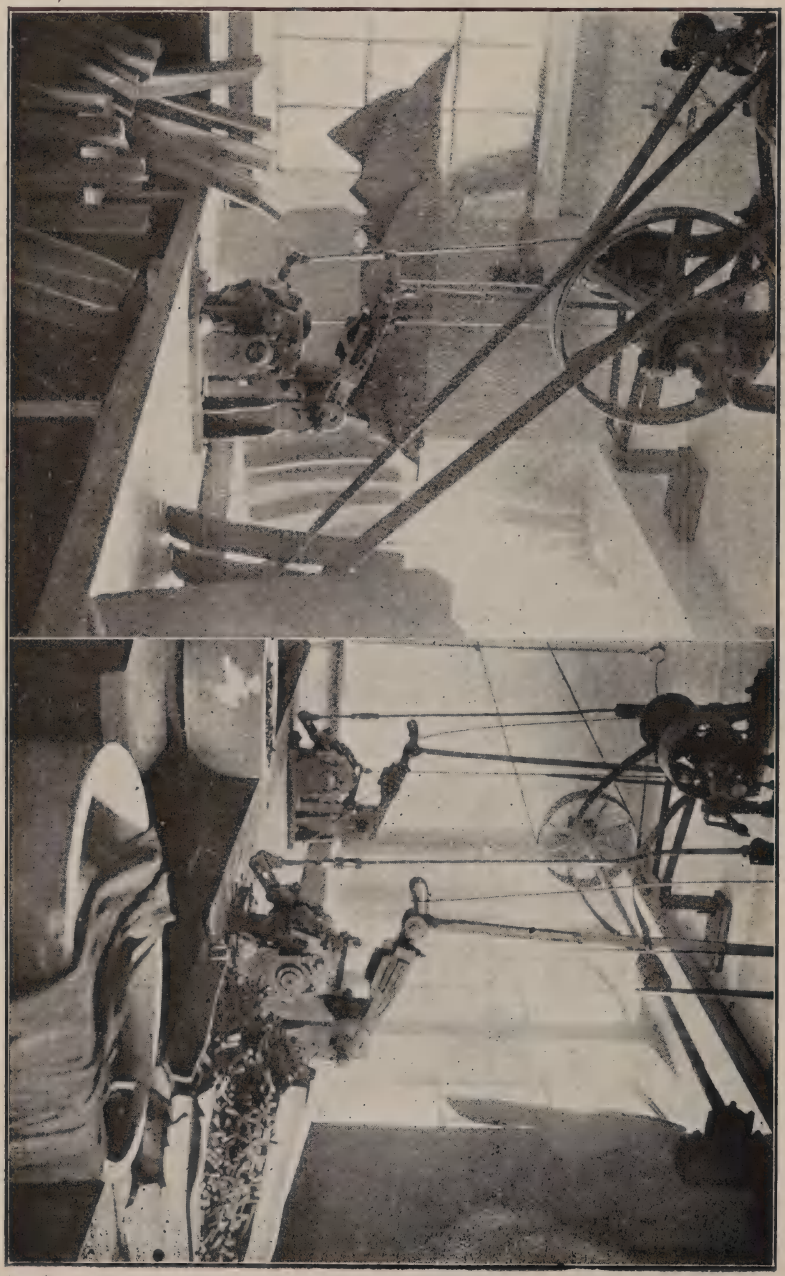

Fig. 12. STILT MAKING MACHINES. Fig. 13.

Proceedings.—Session 1919-20.

General Meeting held in the Central Science Schools, Stoke-on-Trent, on Saturday, 15th October, 1919. Mr. R. L. Johnson presided over an attendance of about 150, including several ladies. The following were proposed as members:—Messrs. Boch Frères, Cie.Gle. de Construction des Fours, Brown & Steventon, (Collective); Messrs. S. Debb, S. R. Hind, B.Sc., L. A. Nicholas, F. B. Newby, C. N. Balappa, R. Gildard, J. Gray, Dr. A. McCance, Messrs. R. B. Sosman, L. Yeatman, D. B. Lockhart, R. D. Chandorkar, B. F. Baker, Major W. R. Snow, Messrs. R. J. Montgomery, W. B. Parker, A. Champion, C. Sexton, A. W. Montgomery, J. Bourne-Wheeler, F. Ruiz, Dr. L. Bradshaw (Ordinary), Miss M. Williams, and Mr. G. M. Horsley (Student). Mr. A. S. W. Odelberg read a paper on "Some New Appliances in Ceramics."

General Meeting held in the Central Science Schools, Stoke-on-Trent, on Monday, the 10th November, 1919. 64 Members were present. Mr. R. L. Johnson occupied the Chair. The following were proposed for membership:—Consett Iron Co. Ltd. (Collective), Messrs. G. Greatbach, S. E. Linbarger, C. E. Hawke, T. Baugh, A. G. Shaw, E. R. G. Corn, A. Woodhead, A. Lee, W. Grocott, (Individual). A vote of sympathy with the relatives of the late Mr. A. H. Ryles was passed. Dr. J. W. Mellor read a paper "The Gelatinization of Clay Slips." Dr. L. Bradshaw and Mr. W. Emery gave a paper entitled "Specific Heats of Silica Bricks," and a short discussion followed. Dr. Bradshaw and Mr. Emery also read a paper on "Some Comparisons between Machine-made and Hand-made Silica Bricks," and a long discussion followed.

General Meeting held in the Central Science Schools, Stoke-on-Trent, on Monday, 8th December, 1919. Mr. R. L. Johnson presided over an attendance of about 84. A vote of sympathy with the relatives of the late Mr. F. Hanchard was passed. The following were proposed as members:—H. Howlett & Sons, The South African Employers Association for the Clay Industries (Collective); Messrs. J. F. Gimson, J. C. Wallace, N. S. Bowen, G. M. Bowen, Junr., J. J. Grover, N. S. Kilner (Individual). A paper entitled "Fine Grinding of Potters' Materials" was read by Mr. L. G. Hill, and a discussion followed.

General Meeting held in the Central Science Schools, Stoke-on-Trent, on Monday, the 12th January, 1920. The President presided over about 66 members. The following were proposed as members:—The Coppée Co. (Collective); Messrs. P. W. Rodger, D. A. Moulton, The Franklin Institute of the State of

Pennsylvania, K. Singh, F. S. Seabridge, W. B. Shaw, C. J. Baines, G. Bhagat (Individual). Acting on instructions from the Council, the Chairman gave notice of an intention to alter the Rules to enable two delegates appointed by the Pottery Manufacturers' Federation to act on the Council. Several short papers were read under the title of "Unestimated Losses in Pottery Manufacture," and a general discussion followed.

General Meeting held in the Central Science Schools, Stoke-on-Trent, on Monday, the 16th February, 1920. Mr. A. Leese presided, and the attendance was about 75. It was announced that the proposed visit to America had to be abandoned on account of the adverse exchange. A letter of apology for absence from Mr. R. L. Johnson was read. The following were proposed members:—The Societe Generale de Carrelages & de Produits Céramique (Collective); Messrs. J. Hewitt, E. Simpson, S. Ball, The Carnegie Library, Y. Y. Wong (Individual). It was resolved that the following be inserted in the Rules:—

4*a* The Council to consist of officers, ex-officers and 12 members of whom 4 shall resign each year, the retiring members to be eligible for re-election.

4*b* The Federation of Pottery Manufacturers to elect two additional members of the Council, one of whom is also to serve on the Publication Committee.

Mr. J. Burton read a paper entitled "The Recent Visit to Some German Pottery Manufactories," and a short discussion followed.

General Meeting held in the Central Science School, Stoke-on-Trent, on Monday, the 8th March, 1920. Mr. R. L. Johnson presided over about 62 members. The following were proposed as new members:—Messrs. F. G. Hewitt, J. T. Wattison (Individual). Mr. A. Heath and Mr. A. Leese read a paper entitled "The Introduction of Lime into an Earthenware Body for the purpose of cheapening it, Part I.," and a discussion followed.

General Meeting held in the Central Science School, Stoke-on-Trent, on Monday, the 12th April, 1920. Mr. D. F. W. Bishop presided. Attendance about 60. The following were proposed as members:—Messrs. V. Bodin, G. Campbell. Mr. B. J. Allen read a paper on "Drying Stoves, Scientifically Designed", and a discussion followed.

VI.—Detective Work in the Potbank.

The Art of Systematised Inquiry (Research) Its Place in Industry.

By Henry E. Armstrong, F.R.S.

> I weigh my words well when I assert, that the man who should know the true history of the bit of chalk which every carpenter carries about in his breeches-pocket, though ignorant of all other history, is likely, if he will think his knowledge out to its ultimate results, to have a truer and, therefore, a better conception of this wonderful universe and of man's relation to it than the most learned student who is deep read in the records of humanity and ignorant of those of nature.
>
> T. H. HUXLEY.

IN what does the Art of Inquiry consist? We must suppose that like other arts it has been evolved but gradually. Although it has been systematised only during a century or so, if we would trace it to its origin we must go back to very early times, when intelligence was beginning to dawn upon mankind—for without inquiry progress is impossible. Giving play to our fancy, we may contemplate some such course as the following, taking as example the case of the common material, Limestone, with which every Potter is familiar.

One peculiarity of limestone, distinguishing it from all other rocks, is the abundance of caves in the formation. In early prehistoric times, the world over, man took advantage of these caves, making them his dwelling places—everywhere evidence of human occupation has been found in them. Even previously perhaps he had learnt to use fire in cooking his food: but whenever this most momentous of human discoveries was made, within the cave, the fireplace will often, if not always, have been built of limestone blocks. Frequent if not constant firing would have caused the limestone to crack and become soft—and from time to time the burnt blocks may well have been cast out as useless from the cave and thus exposed to the weather.

The remarkable behaviour of burnt limestone (lime) when wetted must have made an impression even upon early man—the way in which it grows hot and smokes and falls to pieces and is broken down into a soft, fine powder is so striking, so unlike the behaviour of every other material, burnt or unburnt. The children will have played with the lime as they would to-day and on handling it wet will have "burnt" their own skins, if not their skin-clothes. And not only must the distinction between limestone

and lime, between *mild* and *caustic* lime, have been made in very early times but discovery may have gone much further. Supposing the burnt limestone to have been thrown on to a sandy soil and that when rain came on the lime were not only slaked but more or less washed down into the sand; then that, sooner or later, the mixture became hard: the recognition of such hardened masses may well, indeed must, have been the first step towards the discovery of mortar; but apparently this was not made at an early date, as the Egyptians and even the Romans were not accustomed to its use.

Or taking another case, that of the common mineral known as *Pyrite*, the source of the sulphur given off in burning coal and recognisable, on most coals, in the form of golden scales. This substance is of very common occurrence in concretionary masses, sometimes nodular, sometimes sausage-shaped, sometimes twig-like. The name is derived from the fact that, when pieces are struck together, glowing sparks are produced. There is no doubt it was used in very early times in procuring fire. Pieces have been found together with the rudest forms of flint implements and other relics of human activity.

We may confidently assume that *Pyrite* was so valued that it was collected and stored by prehistoric man. But when kept, if exposed, it soon weathers, becoming partly soluble in water; so that if rain fall upon a heap of the decayed material, some of it is washed away. Suppose the washings were to collect in a pool near to the heap, as the water evaporated during dry weather the dissolved substance would be deposited. As a matter of fact, green glass-like crystals are obtained. The washed heap has a rust-like appearance. The substance produced in this way was long ago termed *Green Vitriol*, vitriol being the generic name given to a number of crystalline, glass-like substances. The early alchemists—the progenitors of the modern chemist—made it their practice to study everything that came to hand and one of the first tests they seem to have applied was that of fire. On heating green vitriol strongly, a dense white fume is given off and on condensing this, a corrosive, strongly acid, oily distillate is obtained—*Oil of Vitriol*, a name which persists to the present day. Testing the effect of this acid on various substances, it was found that when poured upon Nitre, it gave rise to a more volatile acid, termed *Aquafortis*, as it was a solvent of many metals. The jeweller at the present day uses Aquafortis to distinguish spurious from real gold. Sea Salt, in like manner, was found to be acted upon by Oil of Vitriol, fumes being given off which were readily dissolved by water. The fume was called Spirit of Salt and the solution ultimately became known as Muriatic Acid, both names still in common use. In this way, discovery followed discovery, in perfectly logical sequence.

The discovery of the nature of the change undergone by Lime-

stone when burnt was not made until early in the scientific era—by Black about 1755. Much had to be learnt before it was possible to interpret the relationship of the two substances and few were concerned to take interest in such problems. But great as has been the growth of knowledge, even to-day our state is little better than was that of prehistoric man—the majority of us would remain incurious in face of a mountain of smoking, slaking lime. Embryologists tell us that every higher form of individual life becomes what it is, in its passage from the egg, by a process of gradual development from an extremely low form. The same is true of our Society—we can see in it all the forms of far off times. Now not only is mankind the proper study of man but it is the only study in which any large number can take an abiding interest. Nature apart from man has but little interest for most of us.

To recur to limestone, as we scurry about the country the scenery may make some passing appeal, yet as we journey from north to south and cross one limestone formation after another, the fact goes unnoticed. Almost every house in the country is built with mortar, yet no one cares what mortar is but only what mortar does: at most it is so many parts of lime to so many parts of sand. Potters probably are as incurious as the rest of men on the subject.

The fact is, little if anything has been done to develop and extend the art of inquiry—the teaching of the Church and of the Schools for the most part has been frankly dogmatic—the pursuit of truth being evaded, not encouraged. The task before us is, if possible, to overcome this lack of outlook.

The art of the Potter, as now practised, can only have been acquired by trying experiments, in no way random but based upon intelligent observation and the constant exercise of the imagination. Think only of the Potter's Wheel, known from the earliest Egyptian times; most perfectly shaped vessels have been found among Cretan remains dating back many thousands of years. The construction of the wheel must have been an astonishing feat of discovery and invention; probably it involved a whole series of discoveries and inventions.

The Potter is proved by his works always to have been an unconscious investigator and discoverer. Noticing some particular effect he has asked himself and ascertained what would happen if the conditions were slightly varied and has thus unknowingly educated himself in the art of inquiry: in fact, he has constantly engaged in what we now grandiloquently speak of as Research—written with a big *R* and often pronounced with an open *e*, at all events by the Americans, with emphasis on the first syllable:—*R-e-e-search*.

The history of Palissy the Potter is a record of Research; your own Wedgwood Museum is full of proof that the pioneer worker in your industry was an experimenter of the first order.

Mr. Bernard Moore tells me that in considering the composition of glazes, during the war, when it became necessary to find substitutes for materials no longer on the market, he never, in the case of any of the receipts, had to alter the proportions of lime and boric acid, as these were always not only what practice has proved to be desirable but also the theoretical proportions—generations of Potters had hit on just the right proportions to give lime borate.

Mr. Bernard Moore himself is one of the most striking examples I have met of the born investigator. Many of you know his work and can appreciate its beauty; yet few, I imagine, have any conception of the amount of thought behind it. Being a lover of colour and also deeply interested in tracing chemical changes to their origin, I have been greatly impressed, when listening to his explanations of his craftsmanship, as I have realised how largely the effects obtained are calculated. At the outset, he tells me, he had the idea before him that all colours should be obtainable from a single mixture by varying the conditions—and in his ware he has all but realised this dream: reds shade harmoniously into blues and the two become blended in most surprising ways, giving rise to colour forms of wondrous beauty and purity. I am privileged to exhibit three pieces with identical glazes but fired differently: as you see one is red, one blue of a peculiar shade, the third showing both red and blue. In no other ware, I believe, has the control been so fully demonstrated which the potter may exercise over his materials. Mr. Moore is like a musician playing a violin and constantly varying his use of the bow: he varies the fumes of his fire with the conscious object of obtaining mixed effects but instead of playing set pieces he extemporises and the variation is therefore always a surprise and he has the joy of the artist in creating novel effects.

Why is it that Potters have not long since recognised the virtue that is in themselves and given form to an innate quality by making it an expressed habit? The industry rests far too largely upon an empirical basis—mass production has overwhelmed craftmanship; constant exercise of the attention in one and the same direction has necessarily led to a narrowing of outlook; commercial considerations have been allowed to prevail too exclusively. But distant as the Potter is from war, the war has stirred the spirit within him—he with others now realises that the power to use knowledge is power: I say advisedly—*the power to use knowledge*, not knowledge itself, gives power. And this power to use knowledge is scientific method—knowledge used with method to regulate procedure and to procure new knowledge. If I were asked to give proof that knowledge in itself is not power, I should take as example the University of Oxford, which has long been strangely impotent except as a school of manners—in giving social training—because the Oxford man is misled into thinking that he

must know what is known before he begins to add to the sum of knowledge; because he lives too much in the past, too little in the future; because his outlook is literary, not practical, his actions based too entirely on precedent. The power to use knowledge is what is commonly spoken of as science, though it is more properly termed scientific method. Science literally means knowledge but, in reality, the word carries a far deeper and wider connotation—if asked to define it in a single word, I should use the word wisdom. To quote a recent writer:—

"Science is born anew in that wonderful world within each man when, with deliberate will, he succeeds in thinking about the principles of his work in the great world without in a clear, logical and systematic way and courageously puts his conclusions to the test of experiment; and the so-called sciences are the written records of such thinking, only more extensive, clear, systematic and consistent and more true to reality, because they have been tested by countless experiments and experiences in the race.".....

"The more vididly we realise this great truth, that science is continually springing anew from the desires and efforts of men to increase their skill in their occupations by understanding the eternal principles that underlie all dealing of man with nature and of man with his fellow-men (that is, the manual and mental occupations, industry, trade, the professions and so forth), the more vividly we shall see the deep importance of science to all occupations.

"Then shall we recognise also the other side of the relation; for to every action there is always a reaction. If science is continually springing anew from occupations, she has handsomely repaid the debt both by rendering those who follow her teaching more skilled in their occupations and by actually giving rise by her discoveries to absolutely new types of occupations.

"One of the great conditions of the common weal is this unceasing, reciprocal relationship between occupation and science, each constantly producing and being produced by the other."

Janus and Vesta: *Benchara Branford*.

The method of science is in no way peculiar—it is the judicial method, the method of the logician applied to practice, the method of the detective; Huxley has characterised it as organised "common sense."; it were better to say, organised sound sense. What is strange about it is that the subject matter is largely outside the range of human sympathy. The Shilling-Shocker Detective story is universally popular—because it deals with human doings. But who wishes to read a detective story dealing with the discovery of the nature of the crime committed, let us say, when iron rusts? Yet it may well be regarded as a murder of the cruellest kind, as the valuable strong metal is changed into a worthless powder. This is one reason why "Science" makes so little headway in our society; another is that it is necessary to know a great deal, if effective use is to be made of science: the problems are rarely simple. But the principles of scientific method are of universal application and within the range of ordinary intelligence: it is these we need to bring home to the general public. They have not yet been taught effectively, because we are still living in a literary age—we have not yet passed beyond the Oxford stage of evolution: facts, more facts, all the facts in the world, if not what we ask for

is all we receive from the schools. The curse of books is too much upon us. The way knowledge is won, still less the way knowledge is used, is not taught. The teacher-parrot is easily found: the teacher who will refrain from teaching, who will force his pupils to learn and develop them as observant, thoughtful, reasoning beings is almost unknown. No training being given in the art of inquiry, teachers cannot be expected to be inquirers or to lead others to inquire. The danger of women teachers lies in the fact that women are by nature imitative and not original. No handicraft could be learnt if the teaching were on the lines on which the attempt is made to develop the so-called intellectual faculties—mere descriptive talking. The mistake we make is in regarding handicraft work as outside the range of the intellectual faculties: in point of fact, the practice of a handicraft is as much an intellectual exercise as is the construing of Greek or Latin passages which the pedagogues prate of as culture. We shall only succeed in educating the intellectual faculties when we seek to develop them on the lines on which handicrafts are developed—through practice and not through prating. Mr. Fisher, very properly, is seeking to construct a Continuation School System but he has given no thought to the primary need—the provision of effective teachers. However many new buildings we may put up, we shall make no progress, unless we improve our methods of teaching and make them practical—even psychology won't save us. Twenty years ago, a wave of development set in but it received slight encouragement. Now the old gang is recovering its power under the guise of psychology—mainly talk in pedantic terms on subjects of which it is possible to gain very little understanding. It is even invading Pottery preserves. I could not refrain from commenting on the fact when I noticed on the programme of this meeting the title—"Psychological versus Scientific Management." Surely this is sufficiently self-stultificatory; "Scientific Management" must necessarily be "Management with Knowledge"; the antithesis would be management without knowledge. After listening to the paper and the discussion yesterday my feeling is that we need first to learn how to develop the faculties before we proceed to apply tests directed to ascertain ability.

Throughout my career, I have always insisted on the importance of Scientific Method. Somehow, at the close of my student days, I came to the conclusion that there was very little method in science as taught in the schools and that whether or no one became "scientific," not merely a user of receipts, was a matter of chance or luck, so I set to work to study the subject, to train myself and develop a practical system. The one piece of research work I am proud to have undertaken was that I did in this direction. I even published a book of Essays on the subject, which for a time had a fair sale but now the teaching of scientific method is out of fashion; the Professors of Education, being obliged to talk, have

brought so-called Psychological method to the fore. The war should have taught us differently—but has it? The doctrinaire teacher seems to be ever abroad—walking on stilts and talking of culture but giving no thought to cookery and the laying of foundations

Carlyle, chiding Teufelsdröck, long ago summarised the position in saying that "The end of man is an action and not a thought, though it were the noblest." The knowledge gained in the schools, should be of such kind, the training given so imparted that both subserve the purposes of action, bearing in mind that, as Thring, a prince among teachers, long ago, insisted, "the whole human being is the teacher's care"—that we have to educate for the home and the world as well as for wage earning.

Practice is always better than precept, so let me run through a series of examples showing how beginners may be taught method. There are certain cannons that must be followed in such work—you must know what you aim at; there must be some definite object in view, some definite problem to be solved: in practice, the battle is half won when you know what it is you seek to do.

Limestone being one of the commonest and most useful of earthy materials, suppose we select that for examination.

Our object being to determine the nature of Limestone—how shall we begin—how would a detective proceed? The detective would endeavour to ascertain the facts of the case and pick up a clue which can be followed to an issue. What are the facts as to Limestone—what is common knowledge? Is not the name in itself significant? Sand, clay and limestone are earthy materials known to everyone—sand is a granular and clay a sticky earth but neither name carries any particular meaning—limestone is clearly the stone which contains or gives lime. All over the country, wherever there is limestone, there are lime kilns, in which lime is made—how? By burning the limestone: either it is put into the kiln in layers alternately with coal; or the flames and heat from a neighbouring fire are passed up through a kiln filled with pieces of the stone. What is there in the process to arrest the attention? Is it not the strange alteration in character from the mild, inoffensive rock, which through ages has shown itself indifferent to water, to a hot tempered material which violently resents being wetted. Stevenson in his Dr. Jekyll and Mr. Hyde, in his most active fits of imagination, has nowhere pictured a change so remarkable as that from limestone to lime. The fire seems to enter into the stone but that it should be expelled by wetting is passing strange: usually when substances are burnt and reduced to ashes all life seems to go out of them; they are destroyed and dissipated for the most part. Obviously the burning of limestone is a process to be inquired into. What can the lime-burner tell us?

He can tell us how the lime kiln is charged—how often—with

how much coal and how much stone—how often it is drawn and how much lime is taken out—how in the case of chalk-lime the different kinds of chalk give different kinds of lime, the softer a lime which slakes quickly, the harder one which is less easily slaked. If asked how it is sold, he may tell us at so many shillings per load or ton and he may even say about how much limestone will give a ton of lime. On reflection, the information may not seem to afford any very definite clue which can be followed, but as the change is brought about by fire and fire more or less destroys most things, the question may well be put, especially if the lime-burner happen to have told us that the quantity of limestone put into the kiln is a good deal more than that taken out as lime: Is the limestone in any way destroyed, is something perhaps burnt away from it—as in the case of bones?

Here comes the opportunity for an experiment—of obtaining an answer not by talking but by direct action. A quantity of dry chalk is weighed out in a suitable vessel (a porcelain crucible) and heated in a muffle furnace, then cooled and again weighed. The weight is found to be considerably less. The heating, etc., is repeated, to see if there be any further loss; if there be, the heating, etc., is again repeated. The loss is considerable—over 40 per cent. This result may have been an accident—how can it be proved that such is not the case? Surely by repeating the experiment: if the same result be always obtained, there will be no room for doubt. When several experiments have been made and the results tabulated, it is clear that the individual values are of the same order, though not identical: in other words, that the limestone is not volatilised when heated and an amount driven off which depends on the extent to which the heating has been carried but that it actually loses a definite proportion of its weight.

Let me pause here to make two points. In the first place, if instructing students, I should insist on having the argument on which the experiment was based—all the reasons for making it—fully and clearly set out in writing before the experiment were begun and that all that happened in the course of the experiment should be equally carefully recorded at the time: this is part of the discipline and even the most necessary part. Entries made after an event may convey a meaning entirely different from the impression given by an account written before the event; and it is astonishing how easy it is to give a distorted and inaccurate account of an occurrence if this be not written out at the time.

In the second place, the results obtained in such a series of experiments as that suggested afford a most valuable opportunity of driving home certain lessons—lessons on the interpretation of numerical values which have bearing on ordinary business practice. It is customary to buy materials on an Analysis and in specifying the properties of materials numerical values are often introduced—

how are such values to be read, how closely? Those who do not understand what such data imply often attach an almost superstitious reverence to the figures quoted and regard them as of absolute value.

Supposing that in the first experiment with limestone the loss found were 42·56 per cent. and that in subsequent experiments the values obtained were 42·06, 43·01, 42·74, 42·16, 42·32: What are we to conclude—that there is an irregular and not a fixed loss in weight? As a matter of fact, we recognise that we cannot expect to obtain the same result twice—that every experiment is affected with an error. What we do is to add the various results together and divide by the number of experiments—thus deducing an average value: 42·47 in the case considered. Usually about half the results of individual experiments are departures from the mean on the one side and half on the other.

Chalk being one of the forms of limestone, the inquisitor would almost naturally now turn to other limestones and contrast their behaviour when heated with that of Whitening, anticipating, however, that as they all yield lime when burnt they would not differ materially from Chalk. And such turns out to be the case—whether the material be Bath or Portland Stone, the two common varieties of Oolitic Limestone, from the formation represented on the geological map of England by a diagonal yellow band stretching from the S.W. to the S.E. coast; or whether it be Carboniferous Limestone from the North of England or from Ireland. Only Lias Limestone, from the region coloured brown on the map, is found to give a considerably smaller and very variable percentage of lime; but this variety is obviously "dirty in appearance."

Thus the conclusion is established that the formation of lime depends on the expulsion of a something from the limestone. What is this something we may ask? As no fume is observed during the "burning," it is probable that it is air-like and not condensible as steam is.

In such an inquiry, all possible use is to be made of the available information. I have referred to the very general existence of limestone caves. Why should caves be peculiar to the formation? What are the stalactites and stalagmites so abundant in some of them? They are stony icicles which either hang down from the roof of the cave (Stalactites) or rise up from its floor (Stalagmites). Breaking one across, the surface appears to be crystalline. Of what are they likely to consist? Coming from limestone, it is probable that they are a form of limestone—if so they should give lime when burnt. On trial such is found to be the case and the loss in weight somewhat greater—bordering on 44 per cent.—than that of ordinary limestones. Again, when limestone rocks are examined, it is often noticeable that there are cracks in them which have been filled in with crystalline material; sometimes this takes the form of distinct crystals—which are pointed and like

dogs' teeth; the mineral is known as Calc-spar or Calcite. Calcite also gives lime when burnt, losing about 44 per cent. in weight. It is difficult to resist the conclusion that this is the pure material of limestone.

How is limestone formed? it may now be asked. Chalk under the microscope is full of small shell-like shapes; shell remains are recognisable in most limestones; usually the forms are those of sea shells but sometimes the limestone is largely composed of fresh water shells. The carboniferous limestone is full of coral remains and coral, we know, is formed in the sea. Clearly limestone has been laid down under water and it would seem that shells must be made of limestone. We turn to experiment to decide and soon find that lime of high quality is to be obtained by burning almost any kind of shell—not only oyster shells and sea shells generally or fresh water shells but even land shells, such as snail shells and egg shells. Moreover the percentage of lime they give is not far short of that obtained from limestones. When the floor of the Atlantic was dredged by the Challenger expedition, at depths of 2000 feet or more, an ooze was obtained very like chalk in appearance and the minute shell remains in it were recognisable as the shells of organisms living at the surface.

So discovery proceeds—how shall it be carried further and the nature of limestone established? The clue we have obtained must be followed up. Having obtained lime—knowing that it is limestone less something—it is desirable to inquire more closely into its character. It behaves towards water, as we have seen, in an astounding way—water making it hot; as a rule, we do not get hot when we are wetted. Supposing we slake lime not as the bricklayer's mate does but in a scientific manner.—Taking a known weight of lime and a measured bulk of water, we pour the water carefully on to the lime as long as it is absorbed and then note the quantity used. After a time, the lime cracks and falls to pieces and clouds of what is obviously steam are given off; the slaked lime is a dry fine powder. Is all the water added driven off again? It is easy to answer the question by weighing—the weight is considerably greater, about in the proportion of four to three, than that of the lime and nothing is lost on heating to a temperature at which water is easily driven off but only when the slaked lime is heated considerably above the boiling point of water: then water is given off and the lime once again becomes "quick" and restored to its original weight.

Surely this is a remarkable result—that water can combine with a solid and itself become solid in so doing and that the change is attended with the discharge of heat.

The use of lime in making mortar, the peculiar way in which mortar sets and becomes hard, makes lime an interesting subject of study. In preparing mortar, the lime and sand are mixed with water—some action takes place between the two solids, it is clear:

what part does water play, we may ask; may it not dissolve one or the other and so bring them together? It dissolves many substances. It is easy to shake lime or sand with water and afterwards to find out whether either have been dissolved by evaporating some of the clear liquid obtained on filtering the turbid mixture. Little if any sand is dissolved but the lime-water—we call it lime water almost as a matter of course—leaves a substantial residue. The solution has a sweet taste: it is customary to give lime water to babies—when it first came into use I do not know, but its use is evidence that babies have been the subject of experiment in the past.

When it is found that slaked lime is moderately soluble in water, as the inquiry is one involving the comparative study of limestone and lime, the question arises naturally—what effect has water on limestone? Limestone rocks, it is true, are not obviously dissolved away at the sea shore or by the rain: but they are full of caves and it is difficult to explain the origin of these otherwise than by assuming that they are due to the percolation of water, especially as both stalactites and stalagmites appear to have been formed by local dissolution of the limestone and its subsequent deposition from solution; the water too, in limestone districts, is always "hard" and kettles and boilers in which the water is heated become furred—*i.e.*, covered with a hard, stony deposit. The experiment is easily made. Finely powdered limestone is well shaken up with water and some of the clear liquid is then evaporated: very little solid remains. Limestone, in fact, is far less soluble than is slaked lime—it is taken up by water to a surprisingly small extent.

Frequently, perhaps more often than not, discoveries have been made incidentally, not as the outcome of directed systematic and logical inquiry: some chance observation has been made and the discovery has been made when this was followed up. The X-Rays and Radium, of which so much has been heard in recent times, were chance discoveries. Lord Rayleigh, a few years ago, was engaged in determining the weights of known volumes of different gases very accurately—among others atmospheric nitrogen. He found that this was distinctly denser than the nitrogen prepared by various chemical methods. Following up the observation, he ultimately succeeded in separating a small quantity of an unknown gas of greater density than nitrogen—which we now call Argon. Ramsay subsequently showed that, besides Argon, four other previously unknown gases—Helium, Krypton, Neon and Xenon—were also present in air, though in very minute proportions.

In making lime water, it is difficult to prepare a clear solution: the liquid as it runs through the filter may be quite clear but if left at rest the surface soon becomes covered with a pellicle or skin, although when bottled up the solution remains free from turbidity.

When fully exposed, quite a crust is formed on the liquid. What can this be? The deposit is easily filtered off and dried. If slaked lime, surely it should lose water when heated. When the experiment is made, no water is given off but the loss in weight is about 44 per cent.; in other words, the crust behaves like Calcite or limestone-stuff.

We have already concluded, from the behaviour of limestone when burnt, that the loss it suffers is probably due to the expulsion of an air or gas and apparently this gas can be regained from the air. Thus a further clue is developed. Black, with extraordinary perspicacity, one hundred and fifty years ago, came to the conclusion that the deposit was due to the lime attracting a something —which he called fixed air—from the atmosphere. The argument which led him to this conclusion is most ingenious. He tells us, that being surprised at the small amount of sediment produced in lime water on mixing it with a considerable volume of water,

"on account of the air which water constantly contains"; and with a view to know whether water retains its air when fully saturated with lime, a lime-water was made as strong as possible; four ounces of which were placed under the receiver of an air-pump, together with four ounces of common water in a phial of the same size; and, upon exhausting the receiver, without heating the phials, the air arose from each in nearly the same quantity. From whence it is evident that the air which quick-lime attracts is of a different kind from that which is mixed with water. And that it is also different from common elastic air, is sufficiently proved by daily experience; for lime-water, which soon attracts air and forms a crust when exposed in open and shallow vessels, may be preserved, for any time, in bottles which are but slightly corked or closed in such a manner as would allow free access to elastic air, were a vacuum formed in the bottle.

"Quick-lime, therefore, does not attract air when in its most ordinary form but is capable of being joined to one particular species only, which is dispersed through the atmosphere, either in the shape of an exceedingly subtle powder or more probably in that of an elastic fluid. To this I have given the name of "fixed air" and perhaps very improperly; but I thought it better to use a word already familiar in philosophy, than to invent a new name before we be more fully acquainted with the nature and properties of this substance, which will probably be the subject of my further inquiry."

Black knew that in the deposit formed on exposing lime water to air he was dealing with the substance of limestone. How did he arrive at this conclusion? I have pointed out the way in which, in very early times, various acids were discovered and how it was ascertained that they were far more active as solvents than water. Limestone will have been one of the substances on which they were tested—Black was aware that calcareous earths, in their native state, effervesced violently when mixed with acids, whilst quick-lime dissolved quietly; from this he concluded that the former contained a large quantity of "fixed air" which it gave up when sufficiently heated. The modern student, having studied the solubility of limestone and lime in water, might well turn to acids—if only because he knew them to be powerful solvents; but he should be so instructed that he would make his experiments in a systematic manner and measure and weigh everything. Having

found that limestones, according to their purity, lost up to 44 per cent. in weight, he would seek to find out how much gas was given off and would both measure and weigh it. He would have to think out ways of making the experiments. Ultimately he would discover that a definite volume of the gas was obtained and that this was approximately equal in weight to the loss in weight of the limestone when burnt.

This latter correspondence, in conjunction with the behaviour of lime water on exposure to air, leaves little doubt that the conclusion already arrived at was the right one—viz., that limestone consists of lime in association with the gas called Fixed Air by Black, which we may more appropriately term Limestone-stuff or Calcite Gas.

Curiously enough Black never carried his experiments so far as to establish the correctness of his conclusion—by associating the gas given off on dissolving one portion of limestone in acid with lime formed by burning another portion and so reproducing the material of which limestones are mainly and Calcite entirely composed. The modern student detective would necessarily seek to obtain this evidence.

Knowing how easily lime water is affected by air, he would simply bring the gas into contact with limewater—finding a precipitate was produced, he would prepare enough of the deposit to determine its precise behaviour when heated and when dissolved in acid and thus establish its identity with limestone-stuff. He could then write Q.E.D. His quest would be at an end, in so far that he had ascertained the nature of the change undergone by limestone when burnt: that it was resolved into two substances—one a gas, strange to say—though he would not know what either of these were.

But instead of passing the gas directly into lime water, having heard that ordinary so-called soda-water is made by passing Calcite gas into water, he might save himself trouble by using "soda-water" and add this to lime water: finding that a precipitate was obtained, he might go on adding the soda-water, hoping to produce more. Then would come the chance discovery that the precipitate was dissolved by excess of the gas. Think of the importance of this result—of the clue it affords to the large amount of limestone-stuff deposited from hard waters and to the production of caves in the limestone.

I hope I have now made my case clear and demonstrated the way in which the art of inquiry may be taught: how question after question may be asked and the answer obtained by direct experiment; what, in fact, the experimental method involves.

It should not be necessary for me to insist on the value of such training—on the way in which habits of thought, the habit of looking into things, may be developed by it and the tendency thus acquired always to ask for definite evidence in proof of statements

made.

The attempt to bring Science into the Potteries dates back at least 50 years—to the public science classes established at the Wedgwood Institute, Burslem. I am told Sir Oliver Lodge was one of the pupils—that the school was not a perfect one is proved by the fact that it made only half of Sir Oliver scientific; his teachers forgot Thring's precept that the "whole human being should be the teacher's care." In his later years, he has taken to playing with necromancy—I say playing advisedly, because his writings show that he has made no attempt to secure the convincing evidence that would prove he had been dealing with genuine manifestations worthy of serious consideration—the more necessary, as the history of the movement shows that when not the outcome of self-deception it has been largely based upon fraud. But as Carlyle has told us, man is infinitely gullible—our main object in advocating the teaching of scientific method is to correct this tendency. Cases like that of Sir Oliver Lodge show, however, that we cannot hope to go very far: scientific occupation does not necessarily induce the scientific habit of mind: within a particular narrow field a man may be wholly scientific but wholly human in all other fields. Mr. Rudyard Kipling, in the remarkable and entrancing speech he delivered recently on St. George's Day, spoke of our being "promised an unparalled outbreak of education guaranteed to produce a standardised state-aided mind." The gibe is justified. Our minds are standardised by Nature and educable only in a very minor degree and those who are turning to education as the panacea of all evils are doing so in ignorance, regardless of the teachings of natural history. We ever remain haunted by what we have been and cannot break away from its shadows. As Dean Inge in one of his "Outspoken Essays" remarks:—

> "Human nature has not been changed by civilisation. It has neither been levelled up nor levelled down to an average mediocrity. Beneath the dingy uniform of international fashions in dress, man remains what he has always been—a splendid fighting animal, a self-sacrificing hero and a blood-thirsty savage. Human nature is at once sublime and horrible, holy and satanic. Apart from the accumulation of knowledge and experience, which are external and precarious acquisitions, there is no proof that we have changed much since the first stone age".

We may have learnt a few lessons from the war but it has changed neither us nor our neighbours—in the main, men remain selfish in their outlook and cannot well be moved; as education is inherently so difficult a task, a process for which nature has made no provision, it behoves us to be careful to the last degree in our choice of methods.

I suppose the first real outbreak of the scientific spirit in your midst is to be referred to Dr. Mellor's appointment in 1905. It is well to remember that this boon was secured by the late Mr. F. E. Kitchener—one of the wisest of men as an educationist, a man to whom the Pottery district owes much. A temporary school, on the present site, was erected only in 1908 but the agreement

between Stoke and the County for the erection and maintenance of a Pottery and Mining School was not sealed until July, 1911. The building in which we meet came into use at the beginning of 1914 and the war has naturally interfered seriously with the development of the School. But so much has been said of the part played by Science in the war—so much was said during the earlier period of the consequences of the neglect of our manufacturers to avail themselves of the services of scientific workers, that public opinion has been thoroughly stirred. That there is much real understanding of the subject is unlikely—the neglect of experimental teaching by our schools has been so complete that few can have any idea of the value of the experimental method: but there is general willingness to believe in it.

State aided Research Associations are springing up everywhere but I am not aware that any industry, previously unprovided with a scientific staff, has taken independent action. All the Associations have been tempted if not bribed into existence by money grants from the Department of Scientific and Industrial Research; if not a bad sign and scarcely in accordance with our old English habits of independence, this at least shows how far we are from being able to evaluate the importance of scientific assistance to industry. I have no hesitation in asserting that, unless the scientific spirit be carried into the works and until it be made part and parcel of their practice, the movement will be a failure: the mere occasional improvement of a process through information brought in from outside, from a common research laboratory, will not suffice: the information must be used properly, *i.e.*, scientifically, with understanding, if it is to be of real value. This our enemies in the war have long known. The Chemical Factories on the Rhine were visited last summer by a representative deputation of the British Chemical Manufacturers; a summary of the detailed Report on the visit, which was presented to the Association of British Chemical Manufacturers was published recently. A summary of this summary is printed on its title page in the form of the brief four-line statement:

"German chemical industry has been one stupendous organisation for effecting and promoting the application of science to industry."

Organisation has been the secret of German industrial success—the manufacturer has sought to understand his business down to the minutest detail; and he has employed a scientifically trained, skilled staff. We shall not maintain our position unless we follow the example the Germans have set the world.

Proof has already been given of the value scientific assistance may be to the Pottery industry through the work done in connection with the production of Hard Porcelain. Early in 1915, the Governors of the Stoke Pottery School, together with representatives of the Pottery manufacturers of the district, asked the Depart-

ment of Scientific and Industrial Research for assistance in carrying out an inquiry into the methods of making Hard Porcelain similar to the domestic ware produced on the Continent. They had felt to an increasing extent the competition of continental countries and of Germany, in particular, which was sending large quantities of cheap translucent ware into our markets and especially into America.

The Department appointed a Committee (which included Mr. William Burton) to go into the matter and it was arranged that the inquiry should be carried out by Dr. Mellor and Mr. Bernard Moore, at Stoke, the Department undertaking to pay a sum of £7,500 plus three-quarters of the other costs of maintenance.

Owing to the difficulties of obtaining labour and material, it was not until the end of 1915 that Dr. Mellor and Mr. Moore were able to get well under way. A building containing workshops had to be erected and a suitable Gas Furnace designed and built. While this accommodation and equipment were being got ready, Dr. Mellor and Mr. Moore were engaged on preliminary laboratory experiments and in the early part of 1916 they were able to carry out their work on the manufacturing scale. The problem before them was complex, as there were so many different factors to consider. For example, the materials used were to be of British origin; the method of working should be such as could readily be undertaken by a workman accustomed to the more plastic English clays; it was desirable that the ware should be one that could be fired in an ordinary English kiln; the methods of decoration and the palette of colours had to be carefully considered; and finally the cost of the ware should not exceed that of the foreign ware with which it would have to compete.

Eighteen months after the beginning of the experiments the difficulties had in a great measure been overcome and marketable ware produced. One of the most satisfactory results of the work is the designing of a gas fired furnace. This will hold 50-60 saggars; the atmosphere can readily be made either oxidising or reducing and an even temperature maintained throughout the oven.

After Dr. Mellor and Mr. Moore had proved that marketable ware could be produced on a small working scale, they gave 40lbs. of clay to each of 30-40 potters for trial. From these trials they gained a great deal of most useful information as to the difficulties experienced under ordinary commercial conditions and were able to help the manufacturers with further advice. I understand that about half a dozen firms are preparing to produce Hard Porcelain commercially; just at present, however, there is a very great demand for ordinary pottery, due to the cessation of the War, which has to some extent prevented the manufacture of Hard Porcelain on the large commercial scale.

I have advisedly used the word inquiry in connection with this departure. Research, in the past, has been a word of almost

holy import, having been applied to inquiry undertaken with the object of enlarging the bounds of knowledge, without reference to the ultimate value of such knowledge and without taking pecuniary considerations into account. Of late years the term has undoubtedly been vulgarised, all the Toms, Dicks and Harrys and even the Janes occupied in some simple series of routine experiments having dubbed themselves "research" workers.

As you are aware, a British Refractories Research Association was incorporated and registered as a Limited Liability Company only a few days ago. I venture to express the hope that those who conduct this Association will take the long view which has characterised the work of the Geophysical Institute constituted under the Carnegie Trust in Washington, U.S.A. The work of this Institution has been carried out on almost ideal lines—with the object of providing and collating the scientific date required for the interpretation of the phenomena afforded by the crystalline rocks in the earth's crust. Although the work has been done without practical ends in view, at the outbteak of war, when the higher qualities of glass were no longer procurable from Germany and it was necessary to undertake their production in America, the data accumulated at the Geophysical Institute were found to be so complete that the Director was able almost forthwith to take charge of the manufacture, so that satisfactory glasses were soon produced.

No industry offers problems of greater difficulty and complexity for solution than does that of refractory materials—in this country, at all events, practice hitherto has been almost wholly on empirical lines. Success in the future will depend entirely on the extent to which knowledge of the materials and command of the processes is secured—and not only the success of the Refractories industry proper but also that of not a few other industries which use its products. A colossal industry is about to arise involving the carbonisation of coal at low temperatures in order that the volatile constituents may be recovered and used as oil fuel—the economic success of this industry will only be secured if retorts and ovens can be provided which will stand the stress of continued use.

It is therefore to be hoped that the programme of the Refractories Research Association will be directed mainly to central problems. No works should be without a scientific assistant; the larger will need a regular staff: acting under the advice of and in collaboration with the experts attached to the Research Association, the works'-assistants will deal with hand-to-mouth every day problems; without some such organisation the Research Association will not be sufficiently informed as to the problems of the industry to give effective aid in their solution.

At present there is enormous wastage in the Pottery industry through fire cracks, warping of body and carelessness in handling

ware especially at the biscuit stage: great saving might be affected by lessening such losses and that this can be secured through organisation and the introduction of the scientific spirit into works generally is beyond question. Hitherto the attitude of the business man has too often been—"Get thee behind me Science"—in future, if he wish to succeed, he must woo the Goddess of Wisdom and enter into effective partnership with her.

And if Science come to be fully allied with the Pottery industry, I believe Art will also benefit: the outlook will be so much broadened. The scientific worker, to be successful, must have the gift of imagination—he is therefore more or less of an artist. At the present time, many of the "glazes" and "bodies" are very beautiful but the ware is often over decorated—the designs lack freedom and are too conventional—the colour shades are not always satisfactory. To produce a beautiful body and then overload it with decoration would seem to be a mistake. Shape, colour, texture and decoration all contribute to please the eye and the love of colour is undoubtedly growing. We are seeking to elevate the general tone of thought, mainly through formal education: but the indirect education which comes through the influence of surroundings is of far greater consequence. A decorative industry such as that practised by the Potter, therefore, has it in its power to contribute materially to our social advance: let us hope that it may be mindful of this power and regard its exercise as a public duty, remembering that particularly in the case of Pottery—

"A thing of beauty is a joy for ever:
Its loveliness increases; it will never
Pass into nothingness;....."

[We are indebted to the Council of the Institute of Gas Engineers for permission to use this report and the loan of blocks].

VII—Some Comparative Tests of Machine-made and Hand-made Silica Bricks.

PART 1.

COMMUNICATION FROM THE CLAY AND POTTERY LABORATORY, STOKE-ON-TRENT.—No. 94.

By L. BRADSHAW, D.Sc., Ph.D., AND W. EMERY.

IT seems to be generally supposed that fire-bricks made in power-driven compression machines are necessarily inferior to those moulded by hand, although the facts upon which this supposition is based have not been clearly stated.

The early attempts at making silica bricks by machinery were unsuccessful for two main reasons; first, the employment of unsuitable machines, and secondly, failure to recognise the importance of correctly proportioning and tempering the materials. The marked inferiority of the bricks produced in these early trials created a prejudice against machine-made bricks which appears to remain at the present time.

Sometimes machine-made and hand-made bricks from entirely different sources are compared, without regard to the quality and grain size of the materials used and other important factors. Such comparisons are unfair and misleading. The only satisfactory method of testing the question is obviously to compare bricks made from the same materials under identical conditions save for the actual moulding. At the suggestion of Dr. J. W. Mellor we have submitted two batches of bricks prepared in this way to a series of laboratory tests. The result of these tests, given in detail below, are distinctly favourable to the machine-moulded bricks

1 —*The Bricks.*

The bricks were made from crushed Dinas silica rock bonded with lime, one batch by the ordinary hand-process, the other in a power press. They were dried together in the same shed and fired in the same kiln to a maximum temperature of 1380°C.

2.—*The Tests.*

Except where otherwise stated the standard tests specified by the Refractory Materials Committee of The Institute of Gas Engineers (*Trans. Inst. Gas Eng.*, 1918, 97) have been used.

The results may be conveniently divided into two groups, (1) those in which little or no difference is observed between the two classes of bricks (Table 1.), (2) those in which notable divergences are obtained. The first includes the *refractoriness*, indicated by the temperature at which a test-piece begins to soften, the *refractoriness under load* or temperature at which a test-piece collapses under a given pressure, the *reversible expansion* or temporary increase in linear dimensions at 1200°C, the *after-expansion* or permanent increase in size which the finished and fired brick undergoes when subsequently heated at 1350°C, and the *porosity*.

TABLE 1.

	Machine-made	Hand-made
Refractoriness	Cone 33	Cone 33
Refractoriness under load	Cone 26	Cone 26
Reversible expansion	1·2%	1·2%
After-expansion	·355%	·360%
Porosity	25·0%	25·1%

The close agreement between the porosities of the two classes of brick is interesting. It is often taken for granted that the density of power-pressed brick must of necessity *greatly* exceed that of hand-made brick, but this assumption is by no means borne out by actual experiment. The apparent specific gravity of ordinary hand-made silica brick averages about 1·6. The effect of pressure has been investigated by Nesbitt and Bell[1] who obtained the following results:

Pressure under which Bricks were made. Pounds per sq. inch.	187	500	750	1000	1250	1500	2000	2500
Apparent spec. gravity ..	1·50	1·58	1·59	1·63	1·65	1·66	1·67	1·68

The apparent specific gravities of the samples examined in the present case are: machine-made 1·82, hand-made 1·80.

In the second group of tests (Table 2) are included the *crushing-strength*, *spalling* and *resistance to abrasion*. The fact that the

[1] C. E. Nesbitt & M. L. Bell, *Proc. Amer. Soc. Testing Materials*, **17**, 468, 1917.

TABLE 2.

	Machine-made	Hand-made
Crushing-strength (cold), lbs. per sq. inch	2270	1630
Spalling, loss in weight	36%	56%
Spalling, loss in crushing-strength	8·5%	35·5%
Sand-blast, loss in weight in grams	106	143

porosities of the two classes of brick under investigation are practically identical, enables a much closer comparison to be made than if these values were notably different, since the resistance to crushing and the spalling are largely influenced by the porosity.

Crushing-strength (Cold).

The crushing strengths of six bricks from each batch were determined on the Weber machine and the following averages obtained:

Machine-made (edge) 2270 lbs. per sq. inch.
Hand-made (edge) 1630 lbs. per sq. inch.

The resistance to crushing of the hand-made bricks is thus 28% less than that of the machine-made.

Spalling.

Two methods of comparing the spalling have been employed, details of which are given in the Appendix.

In the first, the bricks are alternately heated, and quenched in water. The average loss in weight of the bricks treated in this way was:

Machine-made 36%.
Hand-made 56%

In the second method the bricks are heated very slowly to a moderate temperature and allowed to cool; the resulting decrease in mechanical strength is then ascertained:—

Average crushing strength before and after treatment.

	Crushing Strength lbs. per sq. inch		Decrease in resistance to crushing %
	Before	After	
Machine-made ..	2270	2080	8·5
Hand-made	1630	1050	35·5

It will be seen that in both cases the mechanical strength deteriorated, but the hand-made bricks suffered much more than the machine-made under this heat treatment.

Fig. 1.—Column consisting of four courses of Machine-made Silica Bricks below four courses of Hand-made Silica Bricks. Observe the Sharp Angles and Superior Jointing of the first-named.

Resistance to Abrasion.

This test is described in the Appendix page (79). The average loss in weight of the bricks after exposing to the cutting action of a sandblast for a given time was as follows (six experiments):

Machine-made bricks	106 grs.
Hand-made bricks	143 grs.

or a difference of 26%.

The tests in Group 2 are designed to expose internal weakness due to lamination, cracks and want of uniformity; in these important particulars the machine-made bricks appear to advantage.

Messrs. Nesbitt and Bell found that in six shipments of silica-brick of different brands 60% of the defects were due to moulding. They produced experimental silica-bricks, power-pressed at 1500 lbs. per sq. inch, which suffered no greater loss by spalling than hand-made bricks. The former were superior in shape and it is claimed that "moulding defects such as soft corners, sponginess, improper slicking and lack of cohesion were all eliminated."

Shape.

The excellent shape * and close jointing of the machine-made bricks are illustrated in Fig. 1, where a number of representative bricks from the two different batches are shown. The four lower courses in the diagram are machine-made; the four upper courses are hand-made under the ordinary working conditions prevailing in the factory selected for making the bricks.

In Table 3 are given three series of comparative superficial measurements at fixed intervals round the bricks. Any irregularities are expressed as deviations from the mean of six measurements along each axis. The accuracy of shape of the machine-made bricks is very clearly shown. In eighteen measurements of the width of three bricks of this class no difference is observed; the variation in length is very small, in no case exceeding 1/50 inch. The variations in the hand-made bricks are considerably greater, in one case amounting to 1/10 inch.

It is intended to submit the two batches of bricks to practical tests in actual service.

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*The question of shape naturally applies not only to silica bricks but to refractory bricks generally, since the thinness of the joints in structures is largely determined by the accuracy of shape and the arrises of the brick. Bricks of accurate form joint more closely together; this is a great advantage in many ways, notably in masonry exposed to the action of corrosive materials such as the hearth of a frit-kiln, in which the molten frit may work its way along the joints and completely surround the bricks which are then open to attack over a much larger area.

Table 3—Dimensions.

No.	MACHINE-MADE Length Inches	Departure from mean Hundredths	Width Inches	Departure from mean Hundredths	Thickness Inches	Departure from mean Hundredths	HAND-MADE Length Inches	Departure from mean Hundredths	Width Inches	Departure from mean Hundredths	Thickness Inches	Departure from mean Hundredths
I.												
1	8·97	+1	4·45	—	2·59	+1	8·90	–1	4·42	+2	2·62	+3
2	8·95	–1	4·45	—	2·58	—	8·93	+2	4·42	+2	2·58	—
3	8·96	—	4·45	—	2·57	—	8·95	+4	4·35	–5	2·64	+5
4	8·96	—	4·45	—	2·57	—	8·91	—	4·43	+3	2·55	–3
5	8·95	–1	4·45	—	2·58	—	8·90	–1	4·42	+2	2·57	–1
6	8·96	—	4.45	—	2·56	–1	8·87	–4	4·35	–5	2·55	–3
Mean	8·96		4·45		2·575		8·91		4·40		2·585	
II.												
1	8·96	—	4·45	—	2·57	+1	8·97	+4	4·51	+1	2·63	+3
2	8·95	–1	4·45	—	2·57	+1	8·95	+2	4·50	—	2·58	–2
3	8·96	—	4·45	—	2·58	+2	8·95	+2	4·50	—	2·70	+10
4	8·97	+1	4·45	—	2·55	–1	8·92	–1	4·52	+2	2·56	–4
5	8·45	–1	4·45	—	2·55	–1	8·90	–3	4·51	+1	2·56	–4
6	8·96	—	4·45	—	2·55	–1	8·90	–3	4·44	–6	2·57	–3
Mean	8·96		4·45		2·56		8·93		4·50		2·60	
III.												
1	8·95	—	4·45	—	2·55	–1	8·98	+5	4·43	+1	2·70	+9
2	8·95	—	4·45	—	2·55	–1	8·97	+4	4·41	–1	2·61	—
3	8·96	+1	4·45	—	2·56	—	8·93	—	4·43	+1	2·67	+6
4	8·95	—	4·45	—	2·57	—	8·90	–3	4·40	–2	2·55	–6
5	8·95	—	4·45	—	2·57	—	8·90	–3	4·42	—	2·59	–2
6	8·95	—	4·45	—	2·59	+2	8·92	–1	4·45	+3	2·54	–7
Mean	8·95		4·45		2·565		8·93		4·42		2·61	

Summary.

1 The prevailing objections to machine-made silica bricks appear to be due to prejudice arising from early failures to to produce good bricks from improperly graded mixtures and with unsuitable machines.

2. Of recent years the quality of machine-made silica bricks has been greatly improved.

3 In this investigation, bricks made from the same materials moulded by hand and by machine have been submitted to a series of comparative laboratory-tests. In none of these are the machine-made bricks found to be inferior to the hand-made, while in several important respects, viz : mechanical strength, resistance to spalling and abrasion, and accuracy of shape they are superior.

Appendix.

Spalling Tests.

1. This is a modification of the test used by Nesbitt and Bell. In its present form it is not suggested as a standard test, but simply as a means of comparing the behaviour of the two classes of bricks when submitted to identical treatment. The bricks are dried at 110°C and weighed. They are then placed in a muffle heated to 700°C and kept for half an hour, when they are taken out and one end immersed to a depth of 4 inches in 1½ gallons of water at 15°C for 20 seconds. After allowing to dry in the air for 1 minute, they are replaced in the muffle and the operation is repeated altogether eight times. The bricks are then dried in an oven at 110°C and any fragments which can be readily detached with the fingers are removed. The bricks are again weighed and the percentage loss of weight calculated.

2. Another spalling test based upon that of McDowell[2] is as follows: A number of bricks from each batch were heated together in a gas-fired kiln at the uniform rate of 20°C per hour to 600°C and maintained at this temperature for one hour, after which they were withdrawn, placed at equal intervals apart on an iron tray protected from draughts and left overnight to cool. Some of the bricks treated in this way developed fine cracks; all of them had a dull 'ring.' The bricks were then tested in the crushing machine as before.

Abrasion Test.

As a comparative test of resistance to abrasion, the sandblast method is used. A jet of standard sand is directed against the face of the brick for a given time and the amount of erosion determined by the loss in weight. The test is made in a Mathewson sand-blast machine, especially adapted for this purpose. The brick is clamped at a distance of 7 inches from the nozzle (diameter =0·275 inch) and exposed for 4 minutes to the sand blast at a constant pressure of 7 lbs. per square inch. Under these conditions a deep excavation is made in the brick and internal flaws are liable to be exposed.

DISCUSSION.

Mr. E. M. Myers:—I should like to ask the authors of this paper whether, during the practical tests to which they intend to put these bricks, they will take notice of any difference between the machine-made and hand-made bricks which arises from closer-grained materials lying near the surface. I have had no particular experience with silica bricks, but I know of several cases where firebricks made by machinery have possessed a sort of skin where

[2] J. S. McDowell, *Bull. Amer. Inst. Min. Eng.* **119**, 2047, 1916.

they were made under pressure, whereas hand-made bricks did not exhibit that hardened surface. Perhaps when the authors come to proceed with the practical experiments they will be able to notice whether there is any difference in the behaviour of the bricks which arises from these facts.

Mr. R. L. Johnson:—This question, to a manufacturer, is a very interesting and a very serious one, and I hope that in the course of the practical tests to which Dr. Bradshaw and Mr. Emery propose to subject the respective bricks they will take a particularly bad case of where it is not so much a question of the heat that the bricks will stand, but the draughts. If they could arrange, say, to put a hand-made brick in the mid-feather of one oven, and a machine-made brick in the mid-feather of another, and test the dunting qualities, I think the investigation would prove an extremely useful one. I do not see why a machine-made brick cannot be made of a quality just as good as a hand-made one, but there is no doubt that manufacturers have used haphazard methods in the making of firebricks by machinery. If they would only put as much energy into their machine-made bricks as they do into their hand-made bricks, and take steps to prevent the excessive liability to dunting, I have no doubt that we should all benefit very greatly in this district.

Mr. F. J. Grocott:—I have already put machine-made silica bricks in at the firm of Keeling & Walker, and have found them very satisfactory. But I would like to offer a warning against putting them in where an oven has to be fired up and down. They will not stand repeated variations of temperature. What is wanted, in my opinion, is a good semi-silica brick, machine-made, produced from material very finely ground and magnetised. Then we shall begin to get a brick that will stand the requirements.

Dr. Mellor:—There is an important point about the joints that is brought forward very clearly in the paper. Those who have had occasion to investigate complaints about furnaces, and the life of furnace bricks, must have noticed how very important is this question of jointing. The jointing material is usually of a nature totally different from that of the brick and behaves in the furnace in a different way. When exposed to the action of fluxes, as for instance in the bottoms of frit kilns, the joint is the first point attacked. The jointing clay used has, of course, not been fired and hence suffers a much greater contraction than the brick; if loaded up with grog to reduce this shrinkage the jointing properties of the clay are impaired. The moral is to make the joints negligibly small. It seems to me that a great advantage in the case of machine-made bricks is the possibility they offer of close-fitting joints.

Mr. C. W. Thomas (Communicated):—I have no knowledge of the manufacture of silica brick, so that I cannot discuss Messrs. Emery and Bradshaw's paper from that standpoint.

I should be much interested to see the result of similar tests upon hand-made and machine-made firebricks.

To my mind there should be no question as to the superiority of a properly made machine firebrick, and for the following reasons: (1) Its accurate shape; (2) Its uniformity of composition and structure; (3) Its greater mechanical strength; (4) The possibility of adjusting the grain-size of the clay to suit varied requirements; (5) The ability to use a higher proportion of grog.

None of these factors can be controlled accurately in hand-made bricks, and Nos. 2, 4 and 5, especially are entirely dependent on the skill and the endurance of the moulder, and the proportion of grog used.

In making by hand, the size of grain of the tempered clay is limited by the fact that a moulder's hands will not stand the rough cutting action of grains of grog or clay of any but the finer textures.

Other advantages from a manufacturing point of view are greater speed of drying, with the additional benefit of increased output, and lower fuel costs. If the existing prejudice could be overcome, I do not doubt that all manufacturers would hasten to adopt machine-making for the great bulk of their output.

Mr. W. Emery:—Mr. Thomas, in his communicated remarks, refers to the fact that in the case of hand-made bricks a moulder's hands will not stand the rough cutting action of coarse grog. That, I should think, would be obviated by the use of leather gloves such as are used by makers of silica brick.

Mr. Myers speaks of the close-grained surface exhibited by machine-made bricks. There is no doubt that so far as resistance to corrosion and abrasion is concerned, the bricks will stand much better if they have this dense surface. There is a layer on the outside of the machine-made brick which is undoubtedly more resistant than the core.

With regard to Mr. Grocott's observations, I do not think there is anyone who is intending to use silica bricks for the construction of a potter's oven. All that we are trying to do is to test the two makes of bricks under the same conditions. We know that silica bricks will not withstand repeated alternate heating and cooling. That is not claimed for them.

Mr. J. Holland (communicated):—The spalling tests described are very different from what actual working tests approximate.

While I have an open mind on the subject, I am rather afraid of machine-pressed bricks spalling in actual use when built in a working furnace. If the authors could have given results from

actual furnace experience, say alternate patches of about 8 square feet on the roof, or in the ports of an open hearth furnace either acid or basic (or both preferably) or even on a smaller scale in an electric furnace, it would take us much further than the "fancy" tests they record.

I quite agree with the greater portion of the paper.

Mr. W. J. Gardner (Communicated):—The equal porosity shown in Table I. suggests that the condition of the material used for hand-making was identical with that required for machine-making, *i.e.*, semi-dry; if so, much hand-pressure would be required in the moulding, thereby producing a nearly corresponding density. This is borne out by the specific gravity given for the sample:—1·80 which is 0·30, above the average for hand-made silica bricks. It is not in accordance with practice to find hand-made bricks, as usually understood—made with ordinary wet material—give a density equal to that of "machine"-made bricks, which require a very dry batch if success is to be achieved at all by this method. Hand-made bricks have been, and are commercially made, giving great density and results quite equal to, if not greater than, those tabulated by the authors, but there are many degrees of "hand-made" bricks.

It would be interesting to know why a machine-made brick, resisting so much more pressure in the "crushing" test, than the hand-made brick, should not stand up better than the latter in the "refractory test under load." The two results do not appear consistent. Perhaps the authors can throw some light on this?

The "spalling" tests are too drastic, and in my opinion, spoil any practical value the figures should have. It has been generally observed in actual work that dense machine-made bricks have a greater tendency to spall than hand-made, but much depends upon how they are made, and here again it would be of value to have more inside information as to the composition and condition of the batches and method of making.

Mr. T. Arthur Acton, F.S.A. (Communicated):—These experimental tests are of great interest and seem to me in favour of machine moulding of ordinary sizes of silica bricks. From a petrological point of view a silica brick may be described as having a porphyritic-like structure, made up of phenocrysts and a ground-mass. This structure is caused by the method of grinding the raw quartzite, the coarsely ground fragments being the phenocrysts and the ground-mass being formed of the remainder of the grind and the flour; the proportion of this flour is a matter of prime importance, since on heating, the conversion of the quartz to tridymite, or cristobalite, or both, seems to take place more readily in the finest material of this ground mass. The actual sequence of this conversion appears to me still open to discussion. Fenner is of the opinion that with a flux quartz inverts to cristo-

balite and then to tridymite at temperatures where cristobalite is the unstable and tridymite the stable modification, and this view seems to be rather supported by H. Insley's experiments for the U.S. Bureau of Standards. Messrs. Ferguson and H. E. Merwin[1] claim to have succeeded in converting pure quartz to a mixture of tridymite and cristobalite by the action of dry heat at 1350°C. Anyway, permanent expansion is caused during the inversion of quartz and it is agreed that as large a proportion of tridymite as possible is desirable in a silica brick and that strength in a brick is largely obtained by the interlocking action of the stable crystals. Lime used in the grinding as a bond should theoretically produce a pseudo-wollastonite, but, as a rule, little can be detected by a micro-examination. The American idea that the lime aids in the conversion through its fluxing action may be correct.

I have referred to the petrological side at some length, to emphasize the importance of the grading of the "grind" *i.e.*, the mixture of the raw material referred to by the authors. In America much more attention has been paid to this detail of manufacture than in this country and I agree that improperly graded mixtures and unsuitable machines probably account for the prejudice there has been amongst makers and users of machine-made bricks. It is all a question of "grind." We are much indebted to the authors for these carefully conducted experiments.

THE AUTHORS:—In reply to Mr. Gardner, we agree that there are many grades of "hand-made" bricks. just as there are various qualities of machine-made bricks. The bricks we have tested were made in a factory under ordinary working conditions by experienced men.

As to the behaviour of the bricks under load, there is no known relation between the crushing-strength of a brick in the cold and its refractoriness under load at high temperature.

The objections to the spalling tests raised by Messrs. Gardner and Holland are not unexpected. No satisfactory laboratory test for spalling has yet been devised. Such a test demands visible effects in a limited time and is thus necessarily more drastic than that to which the bricks are submitted in actual use. It is, however, reasonable to suppose that those bricks which are least affected by severe treatment are likely to give the most favourable results under mild treatment. As stated in the paper, we intend to submit the two batches of bricks to tests under service conditions. The result will be communicated in Part II. of this paper.

Mr. Acton has rightly emphasized the importance of grading, but we are of the opinion that the good qualities of the machine-made bricks are not due to this factor alone.

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[1] *Amer. Jour. Sci.*, **46**, 417, 1918.

[We are indebted to the Council of the Institute of Gas Engineers for permission to use this report and the loan of blocks].

VIII.—The Specific Heats of Refractory Materials at High Temperatures.

Part 1.—Silica, Fireclay and Zirconia.

COMMUNICATION FROM THE CLAY AND POTTERY LABORATORY, STOKE-ON-TRENT.—No. 95.

BY L. BRADSHAW, D.Sc., Ph.D., AND W. EMERY.

IN calculating the efficiency of kilns, furnaces, etc., the specific heats of the materials used in their construction is an important factor since it gives an idea of the amount of heat required to raise the kiln to different temperatures. Very little experimental data relating to the heat-capacity of refractories is available, and a value approximating to 0·2 is usually taken as a basis of calculation. S. T. Wilson, A. D. Holdcroft and J. W. Mellor[1] have shown, however, that the specific heat of fireclay increases considerably as the temperature rises, and they assign the value $0{\cdot}193+0{\cdot}00006t$ to the mean specific heat between 0° and 1,300°C. If the specific heat remained at 0·2, 66lbs.[2] of coal (calorific value=8,100lb.-calories) would be required to raise 1 ton of firebrick to 1,200°C, but the increase in the specific heat means that this quantity of fuel would be insufficient. The average specific heat of fireclay brick from 0° to 1,200°C., according to the measurements recorded in Table I is 0·284, and 94lbs. of coal would be required to raise the material to this temperature, *i.e.* 42% more than the first estimate. Silica brick (spec. heat 0·282 at 1,200°) would require a little less, viz.: 93lbs. A striking contrast is presented by zirconia, the specific heat of which at 1,200°C. is only 0·167, or a little more than one-half that of firebrick; one ton of zirconia would be raised to 1,200° by an expenditure of only 55lbs. of coal.

The advantage of knowing the specific heats of refractories is thus evident, and the object of the present investigation, undertaken at the request of Dr. J. W. Mellor, is to determine their numerical values at the temperatures at which they are ordinarily employed. The experiments extend over a range of from 600° to 1,400°C.[3]

The method of determining the specific heat consists in dropping a weighed piece of the material, heated to a given temperature, into a calorimeter and measuring the rise in temperature

[1] S. T. Wilson, A. D. Holdcroft and J. W. Mellor, **Trans. 12**, 279, 1913.
[2] This value is only approximate and a minimum; losses due to radiation, etc., are not taken into account.
[3] W. P. White, *Amer. Jour. Sci.* Ser. IV., **47**, 1, 1919, has determined the specific heats of silicate minerals between 100° and 1400°C. with great accuracy.

produced. The general arrangement of the apparatus is that used by F. Glaser[4] in his work on the specific heat of metals at high temperatures. (Fig. 1.)

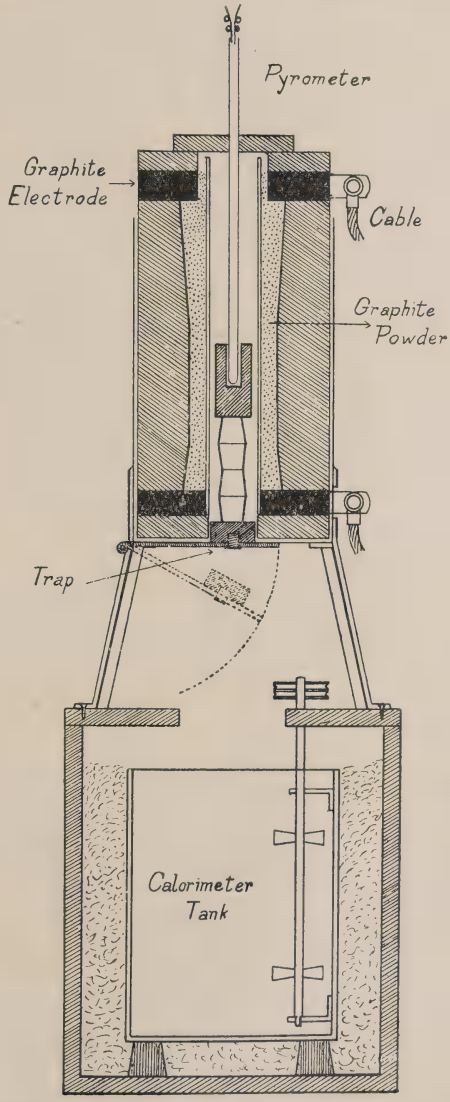


Fig. 1—Calorimeter and Electric Furnace (after F. Glaser).

[4] F. Glaser, *Metallurgie*, **1**, 105, 1904.

Heating the test-pieces.

The test pieces are heated in an electric furnace of the Hirsch type. The inner tube, 24 inches long and $3\frac{1}{2}$ inches in diameter, is of carborundum; it is surrounded by loose powered graphite. By shaping the inner wall of the furnace-case, the space containing the graphite is constricted just below the middle so that a uniformly heated zone of high temperature about 6 inches long is produced in this section of the tube.

The bottom of the tube is closed by a circular slab of firebrick firmly attached to a hinged plate. The charge is supported upon this slab and when the catch is released, the plate swings away and allows the test-piece together with its supports to fall into the calorimeter beneath.

The Calorimeter.

The calorimeter consists of a rectangular iron tank of about 50 litres capacity surrounded by a layer of insulating material and enclosed in a stout wooden case. Two stirrers, driven by a small electric motor, are mounted at opposite corners of the tank.

The splash-breaking device consists of a circular metal tray $3\frac{3}{4}$ inches in diameter and $1\frac{1}{2}$ inches deep, let into the centre of a sheet of copper gauze about 7 inches square which is soldered on to it about $\frac{1}{4}$ inch below the rim. This floats on the water and is prevented from drifting by two catch-pins which pass through small eyelets near the edge of the gauze, and extend just beneath the surface. The charge falls on to the float and is carried to the bottom of the tank. When the buoyancy of the float has been properly adjusted—which may be done by fixing a thin disc of cork underneath the tray, splashing is entirely eliminated and only the merest trace of steam is produced.

Temperature Measurements.

The temperature within the furnace is measured up to 1,100°C by means of a thermocouple. This is enclosed in a sheath of fused quartz fitting loosely into a hole drilled down the middle of the test-piece. Above 1,100°C a Féry Radiation Pyrometer is employed, which is clamped to a bracket over the furnace and focussed on the charge. The thermocouple is calibrated in the usual way at the freezing points of a number of chemically pure substances between 232°C (tin) and 1,070°C (potassium sulphate), and the Féry is adjusted to the readings of the thermocouple between 1,100° and 1,200°C. The indications are checked from time to time during the progress of the experiments.

The temperature of the water in the calorimeter is measured on a Beckmann thermometer reading to 0·005°, the bulb of which is protected from injury by a tubular wire-cage depending from the lid of the calorimeter. The part of the stem outside the

calorimeter allows readings to be made over a range of about 4°. The initial temperature of the calorimeter is adjusted to about 20°C; the final temperature after dropping in the charge is 25° to 26°C.

Test-pieces and Supports.

The test-pieces are cylindrical in shape, $3\frac{3}{4}$ inches long and from $1\frac{3}{4}$ inches to 2 inches in diameter according to the weight required. A hole $\frac{3}{4}$ inch in diameter is drilled along the axis to a point just below the centre of the piece; this form possesses certain advantages, viz: (1) more uniform and expeditious heating of the piece and, conversely, cooling within the calorimeter, (2) more accurate indication of the temperature, due to the position of the thermo-junction at the centre of the piece or, alternatively, the focussing of the radiation-pyrometer on the same spot.

The weight of the test-pieces used at the different furnace-temperatures is such as is roughly estimated to raise the temperature of the calorimeter nearly to the limit of the thermometer-scale after allowing for the heat given up by the supports. The weight varies from 260 to 360 grs. The pieces are cut from trade bricks with the exception of zirconia which, owing to the large variation in the composition of commercial samples, is prepared from the pure material by briquetting in a press and firing at about 1,500°C.

A method of *suspending* the test-piece in the furnace could not be employed as the apparatus required would have interfered with the observation of the temperature. The piece was therefore supported from below and particular attention was directed to the choice of suitable supports; it is essential that these be light, mechanically strong and capable of resisting sudden change of temperature, and they should not shrink much at the very high temperatures employed. Satisfactory results were obtained by the use of hollow cups made of a mixture of 3 parts of china clay with 2 parts of calcined alumina. A column of these cups $6\frac{1}{2}$ inches long weighs only 140 grs., and the proportion of the heat communicated by them to the calorimeter amounts only to about 25% of that conveyed by the whole charge.

Water-equivalent of the Calorimeter.

About 41 litres of water are poured into the calorimeter and stirred for ten minutes, during the latter part of which the temperature is read on the Beckmann thermometer every half-minute. A tared copper vessel containing a weighed quantity of heated water—about 1 litre at 60°C—is then lowered quickly into the calorimeter with continual stirring, and the rise in temperature noted. After making the necessary cooling corrections the water-

equivalent is calculated. The calorimeter filled with water to a mark corresponds, with the splash-breaker submerged, to a weight of 43,450 grs. of water.

The Experiment.

The piece, carefully set upon its supports at a certain height in the furnace, is heated slowly to the required temperature which is maintained for at least half-an-hour. Towards the end of this period the water in the calorimeter is stirred and the temperature observed on the Beckmann every half-minute. At the right moment the sheet of asbestos covering the opening in the calorimeter is removed, the test piece together with its supports dropped in, and the rise of temperature read as before at intervals of half-a-minute. After applying the cooling correction, the rise due to the supports—found by a blank experiment—is deducted, and the specific heat of the material calculated. The experiment is repeated several times alternately with a number of blank determinations.

Results

The values tabulated below represent the mean of from three to six determinations. The departures of the values obtained in successive experiments from the mean is about $\pm$ 2%, as shown in a typical example of the specific heat of silica brick at 1,200° viz.: 0·277, 0·281, 0·285, 0·285, mean=0·282.

Table I.—Mean Specific Heats between 25°C. and t°C. *

Temperature C°	Silica Brick S	Silica Brick L	Firebrick G	Zirconia pure	Stourbridge Firebrick. Wilson and Holdcroft
600	·226	·228	·228	·137	·227
1000	·263	·262	·265	·157	·263
1200	·282	·283	·284	·167	·262
1400	·293	·295	·297	·175	—

These values are plotted in Fig. 2.

S is a silica-brick with coarse grained grog, open texture.
L is a red silica-brick with fine even rounded grains.
G is a Scottish fireclay brick with medium-sized hard grog.
* The analyses are given at the foot of page 89.

It will be observed that the specific heats of all the materials examined are much greater at high temperatures than at ordinary temperatures, *i.e.*, a larger amount of heat is required to raise the temperature of a given weight of refractory through the same number of degrees. For instance, the average specific heat of firebrick between 100° and 300°C. is 0·22, and between 1,200° and

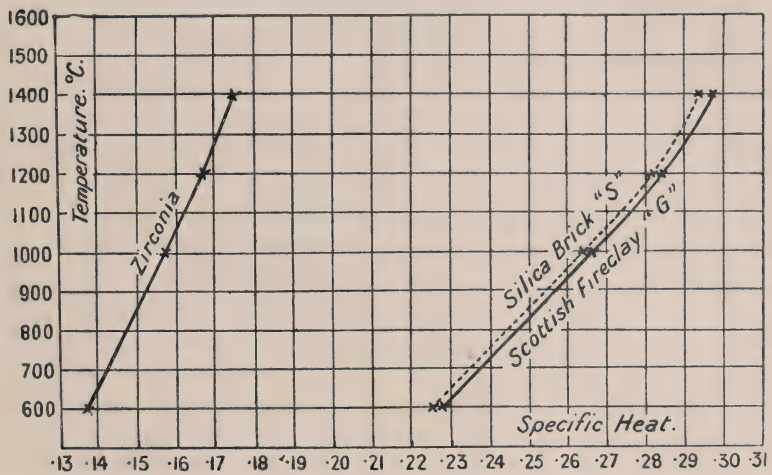


Fig. 2.

1,400°C, 0·36; hence if 22 units of heat be required to raise 1 ton of firebrick from 100° to 300°C., 36 units will be required to raise an equal weight from 1,200° to 1,400°C., although the interval of temperature is the same, viz.: 200° in each case. The fuel consumption at the upper temperature compared with that at the lower, other things being equal, will be nearly as 3 : 2.

The differences between the specific heats of silica brick and fireclay brick are small, as might be expected from the fact that at ordinary temperatures the values for silica and alumina are nearly the same (see Table II).

The specific heats of Scottish fireclay brick at 600° and 1000° agree closely with those obtained by Messrs. Wilson and Holdcroft for Stourbridge firebrick interpolated for these temperatures, but above 1000° the results given by them appear to be considerably too low. Our experiments were not carried below 600°. Assuming, however, that the specific heats of Stourbridge and Scottish firebricks are practically identical at 100°, and that the value 0·194 at this temperature is correct, the mean specific heat of firebrick is—

$$\text{Mean specific heat} = 0{\cdot}193 + 0{\cdot}000075t.$$

Analyses:—

	S	L	G	Stourbridge	Zirconia
SiO_2 ..	96.6	84.65	59.2	67.0	ZrO_2 99%
Al_2O_3 ..	1.2	8.85	35.3	28.0	
CaO ..	1.02	1.90	0.3	0.5	
Fe_2O_3 ..	0.75	4.25	3.0	1.8	

Table II.

Substance	Temperature C°	Specific Heat	Observer
Quartz, clear ..	100 to 0	0·187	White[5]
Quartz, sand ..	98 to 20	0·191	Ulrich[6]
Alumina ..	48 to 3	0·200	Russell[7]
Ferric oxide ..	44 to 3	0·160	,,
Lime ..	150 to 0	0·113	Laschtschenko[8]
Zirconia ..	100 to 0	0·108	Nilson & Pettersson[9]

The increase thus obtained is approximately 25% more than the previous estimate.

The low specific heat of zirconia is remarkable.

It is proposed to extend this work to the investigation of the other refractory materials.

[NOTE: An important paper on this subject by E. Heyn, O. Bauer and E. Wetzel (*Mitteil. a.d. königl. Material-Prufungsamt, Berlin-Lichterfelde*, **33**, 89, 1914.) has recently become available. The authors determined the specific heats of a number of refractory materials including four varieties of fireclay brick of different composition, silica brick and magnesite, at intervals of 200° between 0° and 1200°C. The values obtained for silica brick and the average of four kinds of fireclay brick are as follows:

Mean Specific Heats between 20° and t°C.

	200°	400°	600°	800°	1000°	1200°
Silica Brick	·220	·238	·252	·260	·263	·267
Fireclay Brick	·204	·222	·236	·248	·256	·263

From this, the specific heat of silica brick would appear to be somewhat higher than that of fireclay brick. The difference, however, is small, scarcely exceeding the differences observed between the various kinds of fireclay brick from which the above average is obtained.]

DISCUSSION.

Mr. A. Leese:—Supposing our ovens were to be built with less brickwork, and supported by iron in the same way as a furnace, would not that tend to save a great amount of the heat that is absorbed by the tremendous thickness of some of our present ovens? The heavy brickwork absorbs a considerable amount of the heat before the ware begins to "get up." Then again, would it not make a considerable difference in two ovens differently packed? If, for instance, you had 20 tons dead weight in one oven, and only 15 tons in the next, would you not get better results in the one case with less firing? If you get the saggars filled fairly solidly, with flat ware, for instance, you will find some of the ware in the middle of the saggar hardly fired at all.

[5] W. P. White, *Amer. Jour. Sci.*, Ser. IV., **47**, 17, 1919, and other observers.
[6] R. Ulrich, *Wollny's Forsch.*, **17**, 1, 1894.
[7] A. S. Russell, *Phys. Zeits.*, **13**, 59, 1912.
[8] P. Laschtschenko, *J. Russ. Phys.-chem. Soc.*, **42**, 1604, 1910.
[9] L. J. Nilson and O. Pettersson, *Ber.*, **13**, 1459, 1880.

Mr. F. J. Grocott:—As a practical oven builder, might I be allowed to answer Mr. Leese's question with regard to an oven built with, say, nine inches of brickwork, and metal outside? To build an oven in this way would entail the loss of a great amount of heat by radiation, as the metal would convey the heat from the brickwork to the atmosphere. Therefore, unless there were some insulation between the iron and the brickwork, such as uralite or slag wool, the idea would not be practicable in my experience as a furnace maker.

In a furnace that I built for the enamelling of iron hollow-ware I have an iron plate two feet wide to take the strain off the arches. Now, if you put your hand on the brickwork above or below the iron plate, it is much cooler than the plate itself. You might imagine that you would have greater heat in the region of the combustion chamber, but the heat there is nothing like the same as where you have an iron plate or buckstaff. From this I can only assume that the iron is radiating the heat.

Dr. Mellor:—The second question that Mr. Leese asks, referring to the placing of an oven, is a rather difficult one to answer unless you have a particular case in your mind. For instance, you can place the saggars in an oven so closely together that you may save heat by not getting so much loss through radiation, but you have to remember at the same time that the heating of big furnaces like some of our large ovens is done by the circulation of the hot gases from the firemouths, and if you interfere with the circulation of those gases you are interfering with the proper heating of the oven. If you pack your saggars so tightly that the circulation of hot air cannot take place about the saggar walls, it is necessary to raise the temperature of the inner rings mainly by conduction. The rate at which heat travels through the saggars, through the bedding flints, through the ware and so on, is exceedingly slow, and there is likely to be a bigger difference of temperature between the first and inner rings when the bungs are close together than when they are so placed as to allow adequate circulation of the gases. A curious fault arises when the bungs are set too closely. With tiles, for instance, you get different contractions at different sides of the same saggar. The closer the bungs are placed the less chance the hot gases have of heating the oven uniformly, and the more likely you are to get differences of temperature between the first and second rings.

The Authors:—Mr. Leese has in mind the saving of heat by removing some of the dead weight of the furnace-wall, the structural firmness of which is preserved by a girdle of iron. In this case, however, several factors other than specific heat enter into the calculation. Considering the relatively greater density of iron, which is nearly three times that of firebrick, the saving in weight would not be so great as might at first be supposed. The

specific heat of iron is about one-half that of firebrick, so that on this count a considerable saving would be affected. On the other hand we have the enormously high thermal conductivity of iron as compared with that of firebrick; the substitution of iron for firebrick reduces the insulating power of the furnace-wall. Finally, there is the question of the relative emission or radiation of heat from the respective surfaces, of which we have no data.

IX.—Lime in Earthenware Bodies.

COMMUNICATION FROM THE CLAY AND POTTERY LABORATORY, STOKE-ON-TRENT.—No. 96.

By A. HEATH AND A. LEESE.

THE present day manufacturer of Earthenware views with great suspicion the introduction of lime into his body. Apart from actually adding this material he fights shy of using any materials likely to bring lime in. Why is this suspicion aroused and is it borne out by facts?

We think the general opinion is that lime in a body tends to crazing. During the recent shortage of French Flints and the introduction of chalk flints a regular epidemic of crazing was the result.

At the beginning of session 1918, in a conversation with Dr. Mellor and Mr. B. Moore, on a subject for our work during that session it was suggested that we took this matter up to try and throw a little light on various points raised by previous work and discussion, as Mr. Moore had a very decided idea that if the lime was ground with other material it would act quite differently. In looking up work already done we find a variety of opinions expressed. For instance, Evans (Art and History of the Pottery Business, 1846) gives the following recipe:—

Chalk body.

Ball clay	29
China clay	28
Flint	36
Lime	7

and adds "The lime by promoting the vitrescence of the mass renders the ware very compact, and hence these chalky bodies were formerly in high request because *less liable to craze*. This certainly might be expected as it is well-known that lime renders glass less liable to break from sudden rise of temperature."

The first part of the quotation, viz.: that chalky bodies are less liable to craze, is of course exactly opposite to the present general view. The second part, or argument, why the lime stops crazing, seems to us to be no argument at all. Of course, we must note that no information is given as to firing temperature, or to the nature of the glaze, and both these factors might have a considerable bearing on the final result.

Quoting again from the same author:—

"*Lime in Body*. Flint ground with chert with extra lime in, and no corresponding allowance being made for same, the regular heat fused most of the ware. Mr. Good, of Burslem, had ware and saggars fused together, and the fireman was so astonished that he ran away."

Simeon Shaw also had this remark in his work.

Evans also gives:—

Pin body (very good).

6 Stone
2 Ball Clay
2 Plaster
1 Flint

again showing introduction of lime, but as sulphate.

W. R. Bourne in "Ceramic Receipts" gives two instances:—

Pearl body:—

Ball Clay, ...	16 slop lbs.
China Clay	9
Flint	8
Stone	5
Whiting	1½

Granite Body:—

Ball Clay	15
China Clay	15
Flint	9
Stone	5
Whiting	1

The late Mr. Ashley, of the American Ceramic Society, gave a paper in 1906 on "Additions of Lime to an Earthenware Body," and says, "Calcium Carbonate in earthenware bodies is generally considered as the source of various evils, more especially sudden vitrification and warping," and he thought it might be due to excess and not the nature of the addition. He came to the following conclusions:—

Additions of lime to an earthenware body as Whiting or Fluorspar in amounts not exceeding 3%:—

Increase the shrinkage very markedly.
Decrease the porosity.
Somewhat heighten the translucence.
Very decidedly raises the strength.

We shall refer to Mr. Ashley's body composition later on, but would just call attention to the fact that the temperature in his experiment was cone 3-4, reached in 14 hours, of which the last 4 was at full temperature. His figures were:—

	Shrinkage.	Porosity.	Translucence.	Hardness loss
Normal body	10·5	10·6	1·65	4·94
3% Whiting	12·7	5·4	2·0	2·5

Hardness was tested by loss of weight after grinding in a rumbler a certain time. Incidentally Mr. Ashley adds, "Sudden vitrification and warping were not studied," and these really were the points he set out to test.

The next paper was that of Mr. Teichfeld on the "Manufacture

of Cheap Earthenware," which was read before this Society in 1916, (*Trans.* **16**, 1, 1917,) in which very detailed information is given on the production of lime body. He remarks "In the classification of Pottery in the different handbooks, lime earthenware is said to contain between 15·20% calcium carbonate." In his own bodies, however, he limits the lime (CaO) to 3·75%, equivalent to about 7% calcium carbonate. He got crazing difficulties early on, but was helped by adjusting the grinding and increasing the amount of silica until they reached:—

China Clay	37
Ball Clay	25
Sand	42
Limestone	6

He says:

"When properly fired it gave a very strong and sound biscuit, but many years' experience have shown that the margin of crazing safety was very narrow and any neglect in time of grinding or easier fire brought about the dreaded evil."

He also varied his body according to the kind of clay used, reducing the sand to correspond to extra siliceous clays. In passing we wish also to call attention to the fact that his firing temp. was Cone 3.

In starting our work after talking over with Dr. Mellor and Mr. Moore, we followed Mr. Moore's opinion that if lime be mixed with the stone and ground together there are good reasons for supposing that the old experiences are not applicable.

Our first trial then was to see if lime and stone together gave us as good a flux as stone alone, and if there was any difference in behaviour between simply mixed and ground together.

Our mixtures were:—

Mixed only.	Stone.	Whiting.	Ground together
No. 0	100	—	—
No. 1	95	5	1a
No. 2	90	10	2a
No. 3	85	15	3a
No. 4	80	20	4a
No. 5	75	25	5a
No. 6	70	30	6a
No. 7	60	40	7a

These were fired in China Biscuit and the results show a much more fluxing effect when ground together. This effect is also illustrated by the 2 Cones fired together in which you will see the ground one falls at a considerably lower temperature approximating to 3 cones, than the mixed.

We then made up trials of an Earthenware body with each of these mixtures substituted for Cornish stone.

The body used was:—

	Dry weight.
Ball Clay	30
China Clay	25
Flint	30
Stone	15

and the results showed:—

			Contraction	
	Stone	Whiting	Mixed	Ground
No. 1 ordinary body			6·5	—
No. 2	12½	2½	4·4	5·2
No. 3	10	5	3·0	4·75
No. 4	8¼	6¾	2·5	2·75
No. 5	7½	7½	0·75	2·52
No. 6	6¼	8¾	1·5	0·75
No. 7	5	10	1·0	1·0

In making it was found that the "ground" was much more plastic than the "mixed" and also gave a much stronger body when white hard. These figures are the average of hard and ordinary fire of 4 samples of each number. Attention should be called to the great improvement of colour between No. 4 and No. 1.

These were then glazed and when drawn all gave good bright results with no sign of crazing or peeling. With the work at this stage the session was ended and trials were put away till the present session started in September last. On examining the trials we still found none crazed.

We then decided to make up a good batch of body of No. 4a giving the composition:—

Ball Clay	30
China Clay	25
Flint	30
Stone	8·25
Whiting	6·75

the last two materials being ground together.

We made up about 3 cwts. of body practically on a commercial scale, using the blunger and press placed at our disposal by the Research Committee. The clay was made into plates without any special instructions as to potting. In fact the clay was sent to a manufacturer who kindly had it made in the ordinary course of work. No particular stress was laid as to placing, the only stipulation being that they should be treated just as usual, but we should like one bung of their own in with each of ours to compare as to loss. We found that the loss from crooked, cracked, &c., in our body, was much less than theirs.

Next 2 or 3 dozens were dipped in their ordinary glaze and fired and here we experienced our first set back. They were all crazed. So putting this down to the body being more porous, we got the bulk of the remainder fired harder, previously taking some out

to be dipped and fired in two other glazes. These latter were not used until we saw the result of the harder biscuit fire. But these were all crazed much worse than the ordinary fire. We then tried China Biscuit fire with same result. We then got some ordinary and some hard biscuit dipped in a fritted lead glaze.

In this glaze all the ordinary were good, none crazed, while all the hard fired were crazed; here again contrary to usual practice. Others in leadless glaze gave the same result.

We now thought we were on safe ground to try the ordinary fire in fritted lead glaze printed to see the effect of colours. However, by the time these were out we found that our white ones had begun to craze and the printed ones also have done so now.

Now does this mean that the work is lost? We think not. We then started to see if we could find any explanation for it and we think a few comparisons will make it clear that some changes might be expected.

Let us look at the composition of the bodies. First take Cornish stone compared with the mixture we have used.

	Bases.	Al_2O_3.	SiO_2.
Stone	·668	1·0	7·15
Mixture ..	1·466	1·0	7·15

Here we see at once that we are considerably lowering the silica content. Now look at the total body at the same time comparing them with Ashley's and Teichfeld's bodies;

	Bases.	Al_2O_3.	SiO_2.
Ordinary E'ware.	·154	1·0	4·64
Our New ,,	·439	1·0	4·51
Ashley's ,,	·258	1·0	4·39
Teichfeld's ,,	·350	1·0	4·12

or put in percentages:

Ordinary E'ware.	2·7	25·2	72·1
New ,,	4·15	25·2	71·0
Ashley's ,,	3·34	25·0	71·66
Teichfeld's ,,	3·75	23·0	73·25

showing that our body was higher in bases. Assuming that the firing temperature was in all cases equal, this body should give a more vitreous product than any of the others. The temperature of Ashley and Teichfeld, however, is much higher than the English makers go, Cone 3—4 compared with the English bodies Cone 1. But in our 2 bodies, the ordinary earthenware and our new one are, of course, fired at same temperature, as both were in the same saggar. If then all bases could be assumed to act as fluxes our body should be much more vitreous and the contraction higher. But as you will see from the table the opposite is the case. Evidently then our lime which accounts for the higher bases content does not altogether act as a flux at the temperature reached, although from the ring of the ware it is better than ordinary Body.

Now, however, we have got to look at the fact that the ordinary

fired body dipped in one of the glazes did not craze, at any rate, till sometime after, while the harder fired did craze. Probably in this case the glaze could take up sufficient silica from the body to bring about an equilibrium.

This far in the work brought us to 2 weeks ago and we thought that it would be possible to so arrange a glaze that it would fit the new body without any risk of crazing. To get an approximate mixture for this glaze we estimated the amount of glaze taken up by a body and worked out the approximate formula which showed that we should need to add alumina and silica and boric oxide.

The actual figures are:—

	Bases.	Al_2O_3.	SiO_2.	B_2O_3.
Ordinary body and glaze	1·296	6·58	31·0	·143
New body and ordinary glaze	1·296	2·60	12·0	·08

This trial is now out of the oven. The glaze was not ground very well. but as you will see there is no sign of crazing. Looking at the theoretical composition of the glaze one would think it impossible to fire it at our ordinary glost temperature. Our sole point here was, however, to render crazing impossible. We think that possibly the glaze takes up some of the lime from the body and thus softens.

We went a step further and made up a body without any stone, all the 15% being introduced as Whiting. This was fired in hard semi-porcelain Biscuit, and you will see the trial biscuit plate is quite porous although the contraction is much higher than normal. These plates were dipped in the new special glaze and show no sign of crazing.

As to the sudden collapse of the Lime bodies as mentioned in the early part of the paper we put a few pieces in China Biscuit, but all came out good. The small cream jug (shown) was fired to Cone 11 in 3 hours but no collapse occurred.

Formula of ordinary Glaze:

$$\left.\begin{array}{ll} K_2O & \cdot086 \\ Na_2O & \cdot232 \\ CaO & \cdot351 \\ PbO & \cdot331 \end{array}\right\} \quad .. \quad \cdot32\ Al_2O_3 \quad .. \quad \left\{\begin{array}{l} 3\cdot57\ SiO_2 \\ \cdot386\ B_2O_3 \end{array}\right.$$

Fritted Lead Glaze:

$$\left.\begin{array}{ll} K_2O & \cdot047 \\ Na_2O & \cdot267 \\ CaO & \cdot449 \\ PbO & \cdot237 \end{array}\right\} \quad .. \quad \cdot283\ Al_2O_3 \quad .. \quad \left\{\begin{array}{l} 2\cdot83\ SiO_2 \\ \cdot433\ B_2O_3 \end{array}\right.$$

Leadless Glaze:

$$\left.\begin{array}{ll} CaO & \cdot65 \\ K_2O & \cdot35 \end{array}\right\} \quad .. \quad \cdot4\ Al_2O_3 \quad .. \quad \left\{\begin{array}{l} 3\cdot5\ SiO_2 \\ 1\cdot0\ B_2O_3 \end{array}\right.$$

New Special Glaze:

$$\left.\begin{array}{ll} K_2O & \cdot047 \\ Na_2O & \cdot267 \\ CaO & \cdot449 \\ PbO & \cdot237 \end{array}\right\} \quad .. \quad \cdot533\ Al_2O_3 \quad .. \quad \left\{\begin{array}{l} 4\cdot3\ SiO_2 \\ \cdot983\ B_2O_3 \end{array}\right.$$

We venture to think that this work will go far to enable future research to be taken up with the assurance that satisfactory results can be obtained both as regards Body and Glaze even when Lime is used wholly to replace the mysterious mixture sometimes sold as Cornish Stones.

DISCUSSION.

Mr. J. A. Audley:—Some years ago I had occasion to consult some German technical journals for a special purpose, and incidentally I made a few notes on some other subjects with which I was not immediately concerned at the time. Among these I happened to come across some details as to the composition of bodies in which lime occurred. I may say that both the Germans and the Americans have been in the habit of using a small amount of lime in their porcelains also, and in the case of the Americans at least I think they use a small amount of magnesia as a substitute for part of the lime, reducing the amount of lime accordingly. The object of this is to avoid some of the difficulties that are likely to arise from the use of lime alone, though as it is said to be liable to cause bubbles in porcelain, the amount of magnesia should be kept low.

The composition of one of the mixtures that I have jotted down from German sources (*Sprechsaal*, 1906), was Halle clay 1480, quartz 260, whiting 260. In that case the lime amounts to about 12½ per cent. of the mixture. I presume from the amount of clay utilised that the body was a kind of earthenware, though no particular name was given. The composition in question was said to be used specially for a casting body, 0·12 of soda ash being added.

In *"Keramische Rundschau"* 1911, p. 338, I found a composition given for what was called "a well-tried earthenware body for large and small pressed wall tiles." This was made up of two clays, 94 Lõthain and 26 Colditz respectively, 15½ Hirschau kaolin, 23 of felspar, 46 of quartz, 3 of pitchers and 3 of marble. In this case the lime carbonate only amounted to about 1½ per cent. The writer of the article added that the tiles were dry pressed and fired to a temperature that would be considered rather high for us, namely, Cone 7—8. The succeeding glost fire was only carried to between Cone 03 and 04. It was mentioned that this particular mixture was well-suited for underglaze decoration, aerograph work, transfers and also for decorating in relief.

Another mixture—also earthenware—that was cited in the volume of the same journal, for 1912, p. 16, but fired to a temperature between Cones 5 and 8, consisted of two different kinds of clay in the proportion of 18 Wildstein and 8 Meissen, 25 of fat kaolin, 7 of felspar, 39 of quartz and 3 of calcite or dolomite or magnesite. The remark was made that 20 per cent. of pitchers of the same kind could be satisfactorily put in along with it. A fritted glaze suitable for this is given.

In *"Keramische Rundschau,"* 1912, pp. 20 and 39, three different mixtures were given containing larger proportions of lime, and in these cases the firing was conducted to between Cones 3 and 4. One of these bodies had 20 of Zettlitz kaolin, 30 of white-burning clay (Wildstein), 30 of pure siliceous sand and 20 of carbonate of lime (as calcite or chalk). Another mixture of the same materials but with somewhat different proportions and with the addition of a little felspar (4·75) was intended to be fired at Cone 4. It consisted of 25 kaolin, 25 clay, 30 sand, 15 lime carbonate and 4·75 felspar. Another body to be fired at a higher temperature still—Cone 7—consisted of 20 kaolin, 30 clay, 35 sand, 5 lime carbonate and 9·7 of felspar. Two fritted glazes, one with lead the other leadless, for Cone 08—06, are given.

Some of these compositions were given, not in literary articles, but as answers to correspondents, and I thought they would be of interest to show that such mixtures had been in actual use in Germany.

Mr. A. Heath:—I think I ought to point out here that we have purposely kept away from anything like what are known as vitreous bodies. I could quote numerous instances where, in connection with American hotel china, lime was employed in the body mixture, and in a good many cases where magnesite was used also. What we set out for was to fire at an ordinary temperature and use a certain amount of lime if we could.

Mr. Frank Worthington:—I have had the pleasure of seeing the samples resulting from the work of Messrs. Heath and Leese, and I have been very much surprised in noticing the effect on the pink printing colours. Perhaps the authors can tell us how it is that the pinks appear to have been killed in every case. I would also like to know what stone was used with the mixture of lime. There is such a big variety of stones that I think it would be interesting to have that information.

Mr. A. Heath:—What we used was Cornish stone, not Cornish stone *and*..... As to the pinks, I asked Mr. Leese, if the colours should not come out exactly corresponding to his own, to bring along a piece of his own in order to show the comparison. But I think we might expect pink to go wrong in using any lime bodies. Some years ago I made up a series of underglaze pinks eliminating one of the substances in varying proportions. I eliminated each in its turn. In one series I eliminated lime, and in this case, instead of a pink, what I obtained was more of a liver colour. I made up some trials with a china body and it was surprising that in this case the colour obtained was one of the loveliest pinks one could have wished to see. I showed the trials to Dr. Mellor whose first remark was "There's something wrong." I asked him to consider the matter a little. As a result, he had a pink made up without any whiting at all, and had some pieces printed both on china and earthenware. In every case the china

came out a beautiful pink, whereas the earthenware came out a liver colour. Of course, china, as we know, is largely a lime body and the pink took up its lime from the body. If the pink that Mr. Worthington sees on the table does not suit him, he could have some made up without any whiting, and I think it would give a much better result than pink that contains whiting. Some of the colours at present used by potters would no doubt have to be rearranged if larger amounts of lime were used in the body. The china samples were, I know, of particular interest to Dr. Mellor at the time, so much so that he had the trials repeated in order to assure himself that there was no mistake.

MR. FRANK WORTHINGTON:—I would like to ask Mr. Heath if the pinks displayed are satisfactory to himself.

MR. A. HEATH:—To be correct, I may say that none of them suit me. Incidentally I might add that we had two pieces fired specially in a majolica biscuit. We thought that a majolica biscuit would give a very easy fire, and we had two pieces cast—one thin and the other thick—to see if there were any sign of collapsing in the biscuit oven. The two trial pieces did show a slight sign of crazing, but they were dipped in the ordinary majolica glaze. I do not know anything of the composition of the glaze, but it was noticeable that it did not craze as badly as some of the majolicas that one sees about.

MR. B. J. MOORE:—I would like to ask whether the whiting used in the body was ground with the other materials, or not.

MR. A. HEATH:—It was simply ground along with the stone. In that particular body where no stone at all was used the whiting was ground along with the flint.

MR. H. L. JONES:—It would be interesting to have some information as to the effect upon the colour of the body where lime is added.

MR. A. HEATH:—That point is one of very great importance. I think that the bleaching effect of lime on iron is well-known. In the samples submitted it will be seen that any iron in the china clay, ball clay or stone has been counteracted—bleached—by the lime in the body. The effect seems to be very marked. It will be noticed we called attention to the improvement in color of body between body No. 4 and the original.

MR. W. EMERY:—Can the authors say whether such lime bodies as they have made up would be likely to cause trouble if converted into casting slips with the addition of soda, *i.e.*, if they would give more trouble than the alkaline slips ordinarily used?

MR. HEATH:—I should think Mr. Emery is more capable of answering a query of that sort than I am. I may say that in making up these bodies we did not set out looking for troubles. The point that Mr. Emery raises is an important one and would, of course, have to be considered. It is a point too scientific for me.

MR. B. J. MOORE:—In the old recipes of Josiah Wedgwood, there are mixtures known as "G.G.Frit," and "Composition" which are used to the present day in Mortar, Stone and other bodies, the one a mixture of stone and whiting and the other stone and flint. In each case the materials are ground together for a considerable time on a pan. The mixtures are used in connection with different bodies. I once tried the effect by simply adding the materials ground singly in similar proportions and the results were very different.

This seems to have been something in the nature of an attempt to do what Messrs. Heath and Leese have been doing recently.

MR. A. HEATH:—I have been referring recently to an old book of Billingsley's recipes written in 1817. In many instances he appears to have employed whiting in his bodies, but in every instance this substance was incorporated in a frit before being introduced into the body.

MR. B. J. MOORE:—But in this case the material was not fritted.

MR. W. LINDLEY:—I might mention a point that arose in connection with an experience that I had abroad. We were out for using anything we could get hold of in the way of materials, since we were unable to get supplies from England. We had to find our own bodies wherever we could, and we happened to drop across a supply of limestone. We used it for some months. We were very much charmed with the colour of the body which was beautiful, but our experience was that there was no margin of safety in it. Sometimes in the middle of the oven the body was very porous, and in the bags it was very much shrunk and of a much different colour. After using it for about six months we had to drop it, much to our regret, because we had some lovely colours in our decorations, whilst the body was on the whole very nice and white. We dropped it entirely on account of its erratic results. I would like to ask the authors if their samples varied very much in the case of hard-firing.

MR. A. HEATH:—At the factory where we had our trials fired they never utilized the first ring for the firing of plates, but we prevailed upon them to put some of our plates in their first ring fire. These samples are just a trifle different, but the difference is only slight. The marvellous point was that the easy-fired pieces came out right in the glaze, whereas the hard-fired pieces crazed.

MR. F. TURNER:—May I suggest that one reason—perhaps the popular reason—given for crazing in connection with lime bodies is the fact that so far as the Potteries district is concerned, the lime has been added 5 per cent. this week and 10 per cent. next. When manufacturers have used lime, the source of it has generally been in lime flints. In that case the lime has simply replaced definitely one other material in indefinite amounts.

This is probably the one main reason why crazing has been caused. Had the introduction of lime been better balanced, I do not think crazing would have been caused, certainly not to anything like the same extent. I know myself that lime is already used, more or less unavoidably, ground along with other materials, and personally I think there is some hope of using it intentionally providing it is used in certain definite proportions and an attempt is not made to carry its introduction too far. One would expect an improvement in the colour of the body where lime is used as Mr. Heath has remarked. A cream body, for instance, would be slightly less creamy. With regard to the crazing being more pronounced with hard-fired ware than with easy-fired, possibly an explanation might be that with the easy-fired body the glaze would absorb more lime. A glaze with a high lime content is much less likely to craze than a glaze with a high soda, potash or even lead content. In the case of the easy-fired pieces it may be that more lime has been absorbed, and consequently there is less liability of crazing than in the case of the hard-fired pieces. I should have expected a rather greater difference between easy and hard-fired pieces in the matter of contraction, and I would have expected that to be one of the greatest disadvantages encountered, because if you have any large amount of whiting you will have a large amount of CO_2 given off, and so, in the case of hard firing, one would expect a much greater contraction, as well as a greater liability for crooked. That expectation does not appear to have been fulfilled, however, in the trials shown. I presume, Mr. Heath was wrong when he mentioned Cone 1a as hard fired biscuit. I should imagine Cone 3a at least would have been the minimum for hard-fired biscuit. Some firms would even go to Cone 4a or 5a. I should think Cone 1a would give easy-fired biscuit.

Mr. W. Emery:—Mr. Heath was referring to ordinary earthenware, not to vitrified bodies.

Mr. F. Turner:—I did not think any one would fire so low as Cone 1a unless they were using an extremely high clay content. With regard to Mr. Emery's question as to casting slip, one would expect, of course, that the introduction of lime would naturally interfere with the effect of the alkalies, but I do not think this an insuperable difficulty.

Mr. A. Heath:—As regards contraction, I do not think that I myself would have expected more variation. As to the point raised by Mr. Turner of adding a proportion of lime to an ordinary body, Ashley did it and with only an addition of 3 per cent. he obtained a vastly increased shrinkage. With only 3 per cent. addition of lime he had an added shrinkage of 12·7 per cent. Evidently he must have fired harder. I am not very well acquainted with the firing points of cones. Nor do I know much about Buller's rings. In one case I know we had 49 with a Buller's ring, whereas with the majolica oven it was down to 28. My

own impression is that the difference in contraction is mainly due to the difference in the firing points. When you come to deal with vitreous bodies firing to Cones 4a, 5a, 6a and 7, you do get very high contractions even with lime and magnesite. That is one of the difficulties.

MR. R. L. JOHNSON:—I have been very much interested in the record of the work of Messrs. Heath and Leese, and I hope it will be a stimulus for others to go further. It is indeed a very vital question. Mr. Turner has pointed out that it is not so much the introduction of lime into a body that tends to crazing, but the manner and quantity in which it is introduced. As a rule lime is only introduced to the displacement of flint. If it were introduced merely to the displacement of the stone, probably you would never realise that it was introduced; but when you take out flint and put in lime, it is almost equal to taking out flint and putting in stone, which makes all the difference.

DR. J. W. MELLOR:—I would like to take the opportunity of congratulating Messrs. Heath and Leese on a good bit of work, and I dare say that as soon as the order books of some of our factories are less conjested, the work will have a fairer treatment. Some will no doubt see that the idea at the back of the work is embodied in Mr. Bernard Moore's last paper. We have got very suspicious of lime bodies; they are in bad repute. Whether this is deserved or not is another matter, but there will be some prejudices to overcome before the new bodies developed by Messrs. Leese and Heath receive an impartial trial.

To help in this direction it might be advisable to call them another name,—Calcite bodies, Iceland spar bodies or some name other than lime. The work might then get impartial treatment without the odium of a bad name. I intend to try to persuade them to try an analogous series of experiments with Grecian magnesite in place of whiting. The experience they have acquired with the whiting bodies will serve them in good stead. The Italians have a Magnesite Earthenware and magnesite is used in making sparking plugs. There was also a kind of hard porcelain with steatite as a flux once made in England. I believe that certain good points are possessed by magnesite which are not very marked with the calcite bodies.

MR. A. TEICHFELD:—I have read with great interest the very instructive paper of Messrs. A. Heath and A. Leese on "Lime in Earthenware Bodies."

The concluding part of the paper describing the successful trials with a body in which the whole of the 15% of stone has been replaced by whiting and the plates were dipped in a special glaze, is particularly interesting.

It is to be expected that ordinary replacing of a part of stone by lime is liable to cause crazing, as the content of SiO_2 in the body mixture is thus decreased and if the ordinary stone-ware

glaze has not a particularly wide range of crazing-safety, the ware must craze.

Therefore, when the authors computed a new glaze, which was better adapted to the new body no crazing occurred. The same result was obtained with the body with the (lime) whiting only.

This explains the danger of introduction of lime and partial replacing of stone by lime into the English earthenware bodies, which are invariably stone-bodies, and it seems to me that it may be far less dangerous for a manufacturer of a calcite earthenware to introduce some percentage of stone or felspar into his body-mixture for special purposes, as by doing this he does not shift matters towards the bad end.

It is another question if it is at all advisable to use the two kinds of fluxes, viz.: lime or stone (or felspar) in the same body, as it is by no means certain that these two are good allies in their fluxing action.

I am, therefore, of the opinion that it is safer to manufacture either one kind or the other.

In my paper (*Trans.* **16, 1**, 1917), I described two kinds of calcite bodies. For some time I have been adding a small percentage of felspar to the dinner sets body, but dropped it again, as it was not of great advantage.

X.—Exhibition of Oil Burner from Glass Works.

By Sir William J. Jones.

DR. Mellor and some of his colleagues visited a works recently and invited me to accompany them, since they knew that I was interested in the question of fuel conservation. In the course of the visit we came across an oil burner which, it was thought at the time, might interest some of the members of this society who are more than ordinarily concerned in the question of firing, and as we were able to borrow a burner I was asked by Dr. Mellor to try to explain its working. It is a high pressure oil burner, and the fuel used—a 50 per cent. mixture of creosote and pitch gives the cheapest and most economical working—is introduced to the burner at a temperature of about 100 degrees F. The fuel is maintained at that temperature in storage tanks by means of low pressure steam coils, the tanks being fixed near the roof of the building about 10 feet above the spot where the actual burner operates. The burner, which is the invention of a Mr. Stevens, works under an air pressure of about 60 lbs. obtained from a compressor. The oil is introduced by means of a drip feed, and the air as it passes through atomizes the oil. On the front of the burner is an annulus into which air at the same high pressure is admitted. Round the face of the burner are serrations through which the air passes in a solid ring, so to speak, in order to prevent the atomized oil from spreading too quickly. In this way, a narrow stream of atomized oil and high pressure air is passed well into the furnace. When we saw the burner working, it was heating up a furnace 14 feet long by 8 feet wide containing 8 glass-pots, and the flame temperature was registering 1500 deg. C. The quantity of the oil that the burner consumed was about 16·8 gallons per hour.

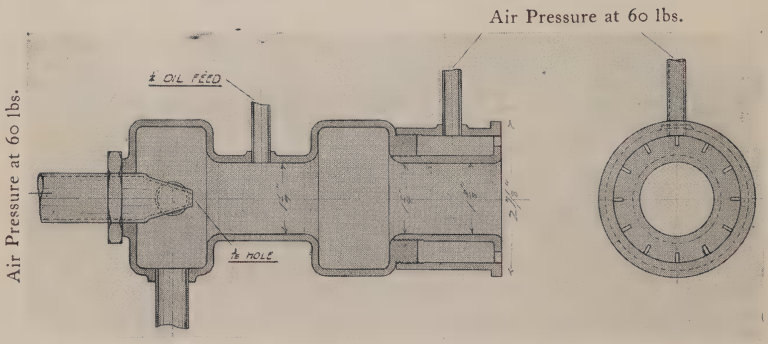


Fig. 1. Plan and Section of Oil Burner.

As to whether liquid fuel is cheaper than solid fuel is all a question of comparison, especially in these days of high prices of oil, whilst another factor which has to be taken into consideration is the locality of the particular factory concerned. I do not propose to enter into the question of comparative costs, seeing that the general question of gas-firing is to be raised at a later stage of the present meeting. We do, however, think that possibly this form of firing presents advantages in certain directions, and should cause some of the members of the society to ponder the point as to whether the primitive methods of firing to which they resort at present might not with advantage be superseded by something of a more modern and progressive character involving the adoption of liquid or gaseous fuel, in connection with which you certainly do get complete combustion, which is not obtainable when firing a furnace with lump coal. Mr. Bailey and Mr. Burton, who took part in the visit to the works in question, were very much interested in this burner and its working from the potter's point of view, and they may like to give you their impressions of it.

I do not think that a furnace of the size mentioned is by any means the maximum capacity for a furnace that this burner can heat efficiently. The users explained to us that, although in the initial stages they encountered difficulties, by making experiments they have been able to realize what they sought to obtain in regard to uniformity of heating, efficiency of heating, and, up to now, economy in heating. The price of oil has, of course, gone up since the burner was installed, and shows a tendency to rise even further. It therefore becomes a question of relative cost as to whether solid, liquid or gaseous fuel firing is most economical in the long run, and that depends very much upon local conditions.

There are many types of oil burners in vogue at the present time, but the one that we have selected to bring before your notice may suffice to interest you in the general question of liquid fuel firing, which I do not think that we, as a Society, have ever yet considered with sufficient seriousness.

DISCUSSION.

Mr. C. W. Speirs:—As a manufacturer of glasspots it is quite interesting to me to hear of the use of this burner as applied to an 8-pot glass furnace. Glasspot manufacturers have been suffering of late from some unknown causes; is it just possible that this is one of them? I was interested to hear, but can hardly realise, that it has been possible, with only one burner of this type, to obtain uniform heat in a furnace with 8 large pots. Oil and gas burners of almost every possible variety have been adapted to our crucible furnaces, as well as coke. Each has its own particular merits. As the price of oil goes up the working costs become prohibitive and ordinary fuel comes into use again.

Mr. Bernard Moore:—No one could help being struck with

the small size of the burner in comparison with the enormous amount of heat that it seems possible to obtain from it. It is quite true that 40 tons of glass can be kept melted in a furnace by a single burner of the type described. Incidentally I may say that it was bottle glass that the burner was melting when we saw it in operation. I am quite sure that the burner could be used for fritting; in fact, there is one installation in this country already in which a similar burner is reported to have been used for fritting with considerable success. If there is one system in the Potteries that is cruder than another it is that concerned with the manner in which we prepare our frits. I am of the opinion that a burner of this kind would be peculiarly well adapted for the purpose mentioned. In a case like this, where we do not as a rule frit continuously for any very long period, a burner which opens out to us the possibility of getting up a temperature quickly and controlling it easily ought, I think, to claim our serious notice.

MR. C. BAILEY:—Speaking from the point of view of the potter, who has had no previous experience of this sort of firing, it seems really astonishing what the burner is capable of doing. The size and capacity of the furnace, the length and intensity of the flame, and the general efficiency secured are something worthy of consideration, and one is forced to reflect how far some similar system might be brought into use for pottery purposes. Much, of course, depends upon a number of circumstances over which we have no control. As the Chairman has observed, the continuity of the supply of oil, its relative cost as compared with coal, and a number of other factors enter largely into the question. I believe the American potters make extensive use of oil firing, but Nature has favoured them very considerably by putting a supply of oil on their doorsteps; consequently they are able to employ it at a very much cheaper rate than we should be compelled to pay for it. High transit charges may militate very seriously against its employment here. I believe it is correct that the Americans estimate on a rough basis that the cost of the oil must not be more in pennies per gallon than solid fuel is in shillings per ton. If it is more than that it is regarded as uneconomical as compared with coal. Still, I have no real data to work upon in this respect. Anyhow, the burner that has been described by Sir William Jones was intensely interesting, and it appears to raise several important points in connection with the ceramic industry. It is quite likely that such a burner could be utilized with economy and efficiency in the fritting process; it also seems to open out a possibility of securing something like standardization and uniformity in the method adopted for the calcination of flints. You are all aware of the crude, even atrocious methods, at present used in the Potteries, and that have been used for so long. It seems to me that the possibilities that are held out in the direction of realizing a more modern method of fritting and flint calcination by an oil burner of the type des-

cribed make it worthy of our serious attention.

MR. J. G. ROBERTS:—Mr. Moore has suggested the possible use of an oil burner, such as that described by our Chairman, in the melting of frits. I have had considerable experience in the melting of enamels with oil burners, a process which needs greater care in the melting than do frits, because of the danger of getting specky enamels. In order to get over the trouble, my firm tried oil firing adapted to an ordinary enamel melting kiln, which is almost identical with a small frit kiln. Quite a number of burners—American and others—were tried, and ultimately I set to work to make one myself. I made a burner which was certainly not one-fifth the size of the one described, which proved capable of dealing efficiently with a kiln containing 10 cwts. of material, and raising this from cold to melting point in four hours. There was no difficulty in getting the burner started; all that it was necessary to do was to soak a bit of tow in oil, light it and so start off the burner. It proved a most efficient burner, and if only oil could be obtained at any thing like a reasonable price it would be economical also. Up went the price of oil, however, and out came the burner.

XI.—The Development of the Tunnel Oven.

By A. Granger.

THE principle of the tunnel oven is wonderfully simple. In the middle of the tunnel the firing places are fixed and the material which is being fired passes slowly through the tunnel at a uniform speed from end to end. It is very difficult to say who was the first to conceive and build such an oven. The earliest paper in which a definite description of a kiln of this type is found is the Hellot's Manuscript[1] in which is described a continuous enamel kiln having some of the characteristics of the tunnel oven.

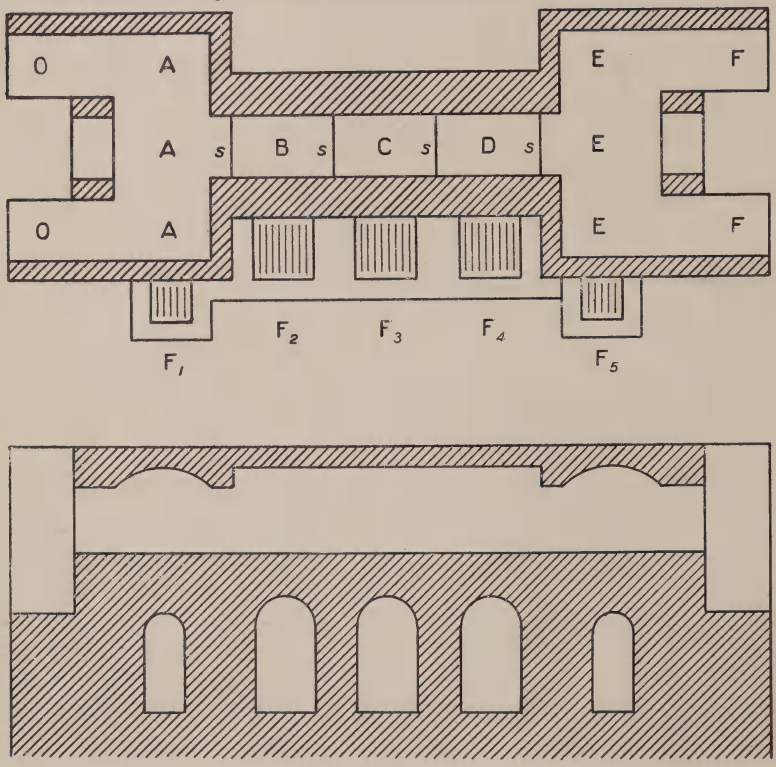


Fig. 1.

Fig. 1. Gérin Enamel Kiln. The ware enters at *O*, is warmed in *A*, heated in *B* and burned in *C*. The cooling begins in *D* and finishes in *F*. The screens between the chambers are indicated by *S* and the firing places by $F_1 \ldots\ldots F_5$.

[1] Bibliothèque de la Manufacture de Sèvres.

This enamel kiln which was built at Vincennes in 1751 by an ingenious worker named Gérin was later transferred to the new works at Sèvres. The inventor was afraid that too rapid heating might damage the ware, and in order to avoid this he devised a suite of chambers in which the goods were gently heated, the firing place of each chamber being placed under the bottom. The temperature gradually increased from the entrance up to the middle of the tunnel where the maximum heat was attained; from there the heat steadily decreased until the exit was reached. A number of extra fire mouths had been inserted in order to prevent too rapid cooling. The ware was placed in baked clay boxes which were drawn and pushed from each chamber into the next, while during the burning screens were installed to separate the adjacent chambers. The Gérin enamel kiln fell into disuse in 1802, the output of the factory being too small for efficient working. In 1809 another Frenchman, M. Legros d'Ainsy erected another enamel kiln on the same principle but with several improvements. Instead of a number of separate boxes he fastened five iron cages together so as to form a train and drew it from the oven by means of a winch and iron chain; this kiln was not designed to burn painted porcelain but decorated earthenware. Although the kiln worked satisfactorily it was demolished after a short life owing to the business being unsuccessful. In both of these kilns the principle of continuous burning was established but neither of the inventors understood the value of recuperation. No improvements of any note are recorded until 1840 when Nordt, in Denmark, and Borrie and Demimuid in France, suggested tunnel ovens for the firing of bricks but without any practical results. However, O. Bock, in Germany, was successful in burning bricks with his "Kanalofen." By this time a new conception had been

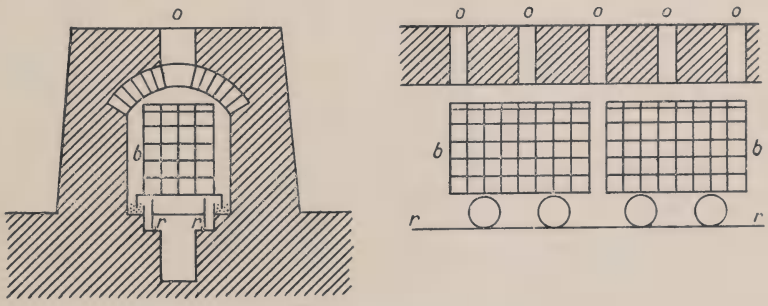


Fig. 2.

Fig. 2. Otto Bock Tunnel Oven. *r* indicates the railway; *b*, the bricks; and *o* the openings in the roof through which the coal is introduced.

introduced. The goods were carried by iron trucks covered with a refractory material and run on a railway; the latter was her-

metically shut off from a movable body by means of curved iron sheets which dipped down into trenches filled with sand and ran along the walls. This oven had several points in common with the Hoffmann and Licht circular kilns. The source of heat was coal which was introduced from openings in the roof and the combustion gases were drawn out from the chimney over the entrance, so that the green bricks on entering the oven were met by a stream of hot gases but later on were cooled by a current of fresh air. This kiln differed from the Hoffmann oven in having a movable bottom and a direct railway. Later on, Bock adopted gas firing. After this, nothing was done for a considerable time and then several more enamel kilns on the tunnel principle were adopted. In these the tunnel was heated externally by firing places near the middle. Furbringer's enamel kiln resembled Gérin's; it consisted of a tunnel externally heated in the middle,

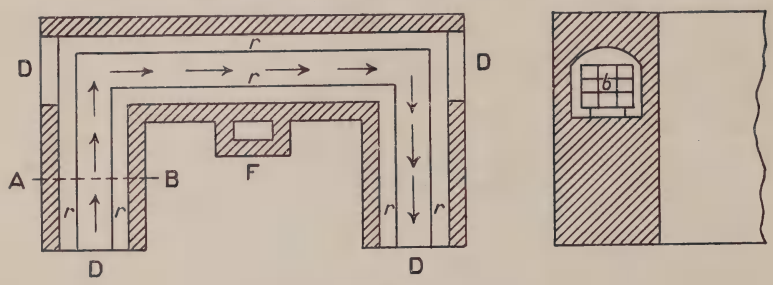


Fig 3.

Fig. 3. Furbinger Enamel Kiln. *F* indicates the firing place; *b*, the basket carrying the ware; and *r* the railway.

the ware being placed in iron baskets which traversed the tunnel on a railway. At the entrance and exit of the main tunnel two short tunnels were built with the direction perpendicular to that of the main tunnel so that the whole resembled a horse-shoe, the idea of this was to diminish the rate of heating and cooling. This type of kiln is still used in many works for enamel firing and hardening on.

The next person to be noticed after Furbringer was Helzel, who designed a circular tunnel. The ware was again placed in iron baskets and carried on wagons as in the Bock oven. This enamel kiln was also used by china manufacturers but its annular form was an objectionable complication. Finally Geith simplified these kilns by adopting rectilinear tunnels with the baskets sliding on rails; the movement of the latter was facilitated by a slight inclination of the kiln bottom. M. Larcheveque, a china manufacturer of Vierzon, has further improved Geith's enamel kiln.

Some 20 years ago the following works: Société des faienceries de Creil et Montereau, and Société des faienceries de Vitryle François at

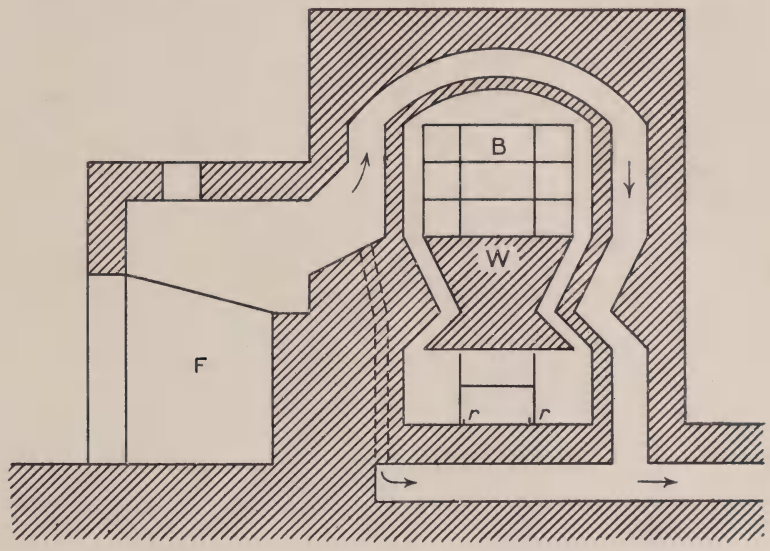


Fig. 4.

Fig. 4. Helzel Annular Enamel Kiln, showing the section through the firing place. *B* is the basket; *W*, the waggon; and *r*, the railway.

Sarreguemines and Digoin, agreed to undertake a combined study of the continuous firing of earthenware. They decided to build a Faugeron kiln at Montereau, a Sturm oven[1] at Degoin and an Ubrich oven at Sarreguemines. The Sturm oven was not satisfactory and had all the troubles inherent in a circular oven; for example, the radius cannot be increased or decreased without demolishing the oven. Similar results were obtained at Longwy. The Ubrich oven also was unsuccessful at Sarreguemines.

The Faugeron oven was much the best of the three and, although originally intended to fire earthenware glost, it was finally adapted by means of various improvements to the firing of biscuit ware. The Faugeron oven consists of a tunnel with the maximum heat in the middle, the ware traversing the tunnel on small waggons which travel against the direction of the gases. The latter are drawn through a chimney near the entrance to the oven; consequently, the flames from the firemouths enter the tunnel at its middle while at the exit end cold air gets into the tunnel and cools the fired ware after it has passed the firemouths. Finally, the gas is passed to the exhaust chimneys. The tunnel has in several places the same section as at the entrance, and there the ware piled on the wagons form a partial obstruction. In order to pass from one compartment to the next, the gases are compelled

[1] *Trans. Cer. Soc.* **8**, 103, 1909.

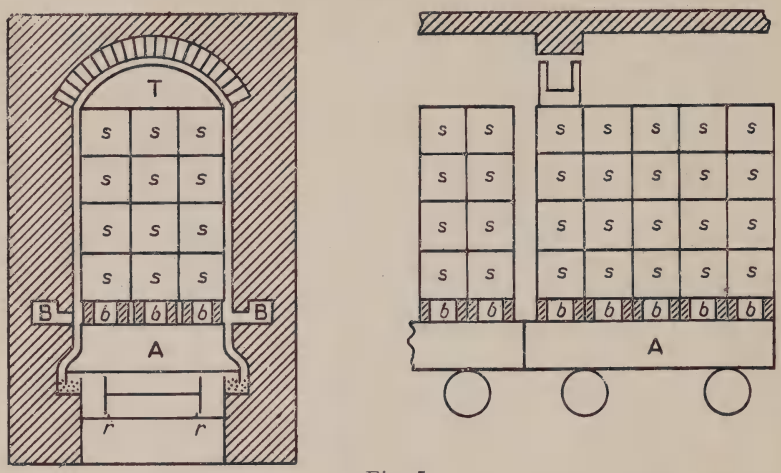


Fig. 5.

Fig. 5. Faugeron Oven. *A* indicates the bed of refractory material; *r*, the railway; *b*, the bricks supporting the bungs of saggars; *T*, the refractory material directing the gas into the channel *B*; and *S* the saggars.

to pass through the side channels. The circulation is shown diagrammatically in fig. 5. As the metallic portion of the waggons must be protected from the great heat they have a thick covering of refractory material and the hot gases only cir-

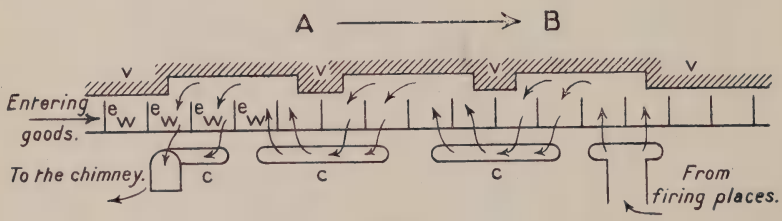


Fig. 6.

Fig. 6. Longitudinal Section of Faugeron Oven. The ware travels in the direction *A*—*B*; *W* indicates the waggons; *e*, the screens; *c*, the side channels; *V*, the drop-arches. The arrows show the direction in which the gases travel under the bottom: another stream passes directly round the screens.

culate above this covering. Throughout the length of the tunnel the introduction of cold air is prevented by means of a number of iron sheets which are on each side of the waggons under the refractory covering and they dip into channels filled with sand; the latter run the whole length of each side of the tunnel. The metal frames of adjacent waggons are connected by means of asbestos sheets. The leakage of air at the entrance to the kiln is

prevented by one of two methods; (*a*) by a lock into which the waggons are led or (*b*) by piling up the goods on the waggons so that these rub against the lining of the entrance to the tunnel. The heating and cooling of the ware is carried out by controlling the circulation of the gases through the whole length of the tunnel. In order to avoid easy firing, the gases are led behind a series of baffles by means of a number of pipes placed in the tunnel walls. At the present time many ovens of this type are working at Montereau and elsewhere. The Faugeron oven has also been tested in Germany and has been used successfully in firing porcelain at Altwasser in Silesia. Another well-known kiln which is being used in England is the Dressler Oven, but it is unnecessary to describe this further as published descriptions are available.

At the present time experiments on the tunnel oven are being carried out at Limoges, but it is too early to judge whether it is successful or not. With regard to the future of the tunnel oven, I think that electric heating should cause a great improvement as my own experiments in the laboratory at Sèvres have proved that electric heating can give satisfactory results. In a horizontal oven heated with small coal I managed to fire china successfully. One difficulty, however, had to be overcome; the carbon monoxide which was produced leaked from the corundum pipe and strongly reduced the body, so that the pieces had an unpleasantly grey colour. By introducing air from a small chimney the reduction was sufficiently decreased so that the ware was white.

XII.—Psychological versus 'Scientific' Management.

By Charles S. Myers, M.D., Sc.D., F.R.S.

Of recent years, efforts have been made to introduce from the United States into this country a system of industrial organisation known as "Scientific Management." These efforts have been far from successful. The British workman is generally opposed to Scientific Management and the cause of his attitude is not hard to find. It has arisen partly because a system which has met with some success in one country has been introduced without modification or comprehension into another where the conditions of labour are obviously different. But a still more fundamental cause of failure is that Scientific Management, *as originally advocated*, cannot be expected to be generally or permanently successful in any civilised land. At a recent meeting of Electrical Engineers in London, where a paper was read by an enthusiast in praise of "Scientific" Management, one speaker after another criticized the system adversely on the grounds that it did not take sufficiently into account the human aspect of the problem. This criticism, coming from engineers of this country, is important, seeing that the father of the movement, Frederick Winslow Taylor, and many of its subsequent early advocates, have been themselves engineers. They have not unnaturally tended to concentrate on the machinery of production, and consequently they have inclined to regard the employee too much as an inanimate mechanism rather than as a human individual who has instinctive, emotional and intellectual activities of his own; they have too often treated him as little more advanced than an animal, as an organism which has above all to be broken in to obey. To "Schmidt," the man whom Taylor selected for his first motion study pupil in the handling of pig-iron at the Bethlehem Steel Co.'s Works, he explained "You know just as well as I do that a high-priced man has to do exactly as he's told from morning till night." (Sc. M. 45).* For a Pennsylvanian Dutchman, for one who fulfilled Taylor's requirements for successful pig-iron handling—namely "that he shall be so stupid and so phlegmatic that he more nearly resembles in his mental make-up the ox than any other type" (Sc. M. 59),—for such a man Taylor's injunctions of implicit and eternal obedience may at first sight seem in place. But I doubt very much the real wisdom and appropriateness of adopting such an attitude before any worker in any occupation

* The references Sc. M. and Sh. M. throughout the paper are to F. W. Taylor's "Principles of Scientific Management" (Harper and Brothers, 1916), and "Shop Management" (Hill Publishing Co., 1911), respectively.

in any country. I doubt whether man is even of the "ox type," unless he is forced into it by his environment, by years of authority and by early suggestion. Only the other day I was hearing the description by a welfare supervisor, how the girls under her care generally showed keenness and interest in their work as newcomers, anxious to learn and to understand, and how in the course of a few months they become listless and apathetic, bored with the monotony of their work, blind to any possible improvements in it,—a herd of dull, unintelligent, well-trained animals (shall we say "sheep" instead of "oxen"?). Implicit, immediate obedience, with suppression of independent thought and initiative, was the old military ideal; the army machine soon "broke" him who attempted to redress injustice or who sought to introduce progressive methods. If discipline, essential as it is in the world of labour, is to be reduced to this dead level at which every spark of initiative and of self-expression is smothered, can we be surprised that the worker resists to his utmost that ideal of Scientific Management in accordance with which (to quote Taylor's words) "the managers assume.....the burden of gathering together all the traditional knowledge which in the past has been possessed by the workmen" (Sc. M. 36)? Can it be supposed that mechanical obedience, coupled with high wages and diminished effort, affords adequate compensation for the loss of individual craftsmanship? "No worse mistake," says Taylor, "can be made than that of allowing an establishment to be looked upon as a training school, to be used mainly for the education of many of its employees." (Sh. M. 1419). I have no hesitation in retorting that no finer ideal, no aim more in consonance with the industrial spirit developing in this and other civilized countries, or more likely to check blind revolutionary tendencies, can be kept in view than that of allowing an establishment to be looked upon as a training school for the education of its employees. If, as I believe must come, the craftsman's secrets, and indeed all so-called trade secrets, are to be general property, like the scientific discoveries of professional workers, if, as seems inevitable, specialisation must ever increase, then the boredom of narrow monotonous occupation must be safeguarded by a wider training of the worker, by his wider knowledge of the factory or business of which he forms so small a unit. If "Scientific" Management aims at turning the workers into an obedient machine, "Psychological" Management regards him as a human being and hopes to invest him with as much knowledge of, and as clear a voice in the control of his industrial surroundings as is compatible with efficient management.

Such treatment as that which I have just criticized may have some success in a new country like the United States, so long as there is a plentiful supply of labour, and a correspondingly rapid stream of immigration. High wages, says Taylor, is what the workman wants most . But does anyone believe that high wages

offer an adequate inducement for vastly increased output, or that high wages without a vastly increased output are not immediately accompanied by increased cost of living so that the worker is not a bit the better off? A higher standard of living is certainly one of the principal ambitions of the working classes, but that is not the sole motive for his unrest and his lessened output. He is also moved by jealousy and suspicion towards capital. He envies the luxurious motor cars of the directors and shareholders for whom he works, and the rich furs, the extravagant dresses, the more varied amusements, the better facilities for education, enjoyed by their wives and children. He believes that capital has hitherto taken an excessive share of the profits of his work. He refuses point blank to accept Taylor's dictum that "all employees should bear in mind that each shop exists, first, last, and all the time, for the purpose of paying dividends to its owners" (S.M. 1419). Is not this opinion alone sufficient to damn "Scientific" Management in the eyes of labour in this country? In the United States, the first patrons of the movement employed it in order to fight Trade Unionism. In this country we recognise that the errors of Trade Unionism are to be removed rather by better mutual understanding and education. The old opposing camps of capitalist and worker can only be harmonized under the common ideal of what, for want of a better name, we call Social Service. As well might the officers of an army claim that their soldiers only existed to bring them fame and glory, if management is to claim that the working classes exist solely for earning dividends, solely for production.

Two of the most important elements of "Scientific" Management are the task and the bonus (Sc.M. 122). "Each man in the establishment," says Taylor, "high or low, should daily have a clearly defined task laid out before him. This task.....should not be easy to accomplish" (Sh.M. 1368). The task is to be such as requires a first-class man to do his best (Sh. M. 1441). It is to be determined by time-study, and a standard time is to be set in which the task can be performed. The standard time, says Taylor, is the quickest time in which a job can be done by a first-class man (Sh.M. 1365). But "it is useless" says Taylor, "to assign a task unless at the same time adequate measures are taken to enforce its accomplishment" (Sh. M. 1372). Its accomplishment is to be enforced by Taylor's system of payment. This is so devised that the less expert or less industrious worker comes to earn so little that he cannot afford to remain on the job. Taylor's ideal is to secure first-class workers for "Scientific" Management and to exact from them their maximum output. The first-class man, he finds, can produce from two to four times as much as the average man, and will do so if paid from 30 to 100 per cent. above the average wage (Sh. M. 1345). He says that "the greatest prosperity can exist only.....when each man and each machine

are turning out the largest possible output" (Sc. M. 12). "What is needed," according to Taylor, "is a hand-book on the speed with which work can be done" (Sh. M. 1442). So he proceeds to time the working movements, and he introduces into the works his stop watch openly if possible, or, if need be, concealed in a sham note book. "There are many cases," he says, where secret timing is unavoidable. (Sh. M. 1426).

The futility of adopting such methods in this country and the economic fallacies involved in such ideals are surely too obvious to need detailed exposition. Single factories in this country cannot hope to engage only first-class workers. Employers' federations and trade unions would soon assert their power to prevent it. I know of a managing director who reduced the hours of work and increased the pay earned by his men in return for their largely increased output obtained by motion study and training, and he was soon removed from membership of his employers' federation. I know of another, who, when the manifest advantages of certain slight changes were proved to him, would not venture to adopt them without the approval of his employers' federation. The employers are not going to allow any one factory to monopolise the most capable workers. The more efficient man does not necessarily put forth greater effort than the inefficient to secure his higher and better output. Rightly or wrongly, many trade unions fear that payment by task, or even by results, means the over-driving of the average and the below-average worker, and the entry of a bad spirit of jealousy, rivalry and suspicion into the workshop. Rightly, perhaps, this attitude has been adopted in view of the experience of the past; doubtless wrongly in view of a more harmonious and better organized future. It rests with the trade unions to see that none but sufficiently qualified men are admitted to the full privileges of Trade Unionism. It rests with them to exclude grossly inefficient workers, just as the General Medical Council and the Incorporated Law Society exclude imperfectly trained doctors and lawyers—namely by enforced training in specified subjects for specified periods and by adequate examination. It is by these means that the medical and legal professions prevent over-crowding—especially by raising the standard of examinations.

Another well-recognised cause of trouble which besets the system of payment by results is the fear of rate-cutting. A further cause of trouble which prevents each from doing his best is the fear that his weaker comrade will suffer and that with increasing output there will be increasing unemployment. Until guarantees can be offered that the rate once set will not be cut so long as the conditions of work remain unchanged, and that a man will not suffer when thrown out of employment through no fault of his own, no system of payment by results can hope to be really satisfactory. To investigate and to suggest remedies for such fears and suspicions is the sphere of the applied psychologist, not of the engineer

or other expert mechanician. The best can no more be got out of a worker who is suffering from mental discomfort than out of a worker who is suffering from bodily discomfort. A specialist, trained in the methods and principles of psychology—the science of the mind—and of physiology—the science of the living body—is now fast becoming recognised as essential in all large industrial concerns. Those who realise the enormous contribution made by psychology during the war to the treatment of cases of nervous breakdown, will readily appreciate the value of psychology in conditions of industrial unrest. Already in the United States, the crude blunders made by "Scientific" Management at its inception are being repaired by the engagement, in various factories and commercial houses, of men trained in psychology and physiology. A National Institute of Psychology and Physiology applied to Industry and Commerce has just been established in this country. Its chief objects will be to train those who wish to take up this kind of work; to undertake special problems in any individual factory or firm when so invited; to establish and apply tests by which applicants for work can be selected according to the occupations for which they are bodily or mentally best fitted; to study and to determine the most favourable conditions which tend to the mental and bodily health of the worker and to harmony and co-operation between management and labour. Various Trade Unions and Federations of Employers are viewing the establishment of such an Institute with favour, because they feel that, conducted by a body of trained scientific men, without profit, by scientific methods, and without ulterior motives, it can be approached from each side for an absolutely impartial solution of the various problems that confront them. Some of these problems I venture to point out to you in this paper. But before leaving aside any further specific mention of the Institute, I would point out the magnitude of its task and its national importance, and I would draw attention to its need of further immediate financial support.

I proceed now to a consideration of the various inquiries, initiated by or comprised in "Scientific" Management—in order to indicate how in each case the psychological factor must be taken into account, unless that inquiry is to be predoomed to failure.

Let me return first to motion study and time study, which have been elaborated especially by Taylor and Gilbreth, neither of whom, however, had psychological or physiological knowledge adequate for the work. I will leave aside the reprehensible procedure of spying with a stop-watch on a man at work without having first obtained his consent. The "Scientific" Management expert proceeds to divide up the job into a number of small elementary movements and to "study" (I quote Taylor's words) "with a stop-watch the time required to make each of these elementary movements and then select the quickest way of doing each

element of the work," and finally to "collect into one series the quickest and best movements" (Sc. M. 117, 118). A variety of psychological errors is contained in these sentences. First, it is assumed that the quickest movements are necessarily the best. But best for what? Does it necessarily follow that the quickest way of doing a job is the best way of getting the best quality of output or the least amount of spoilt work? Does it necessarily follow that the quickest way of doing a job involves less fatigue for equal output? An engineer, one would think, would not have confused the quickest with the best way of running a machine. How much more caution and preliminary work must be needed in the case of the living human mind and body?

Secondly, it is proposed to combine together the quickest ways of doing each element of the work, and thus to reach a standard time and a standard method of carrying out the entire job. Each worker is to be trained in this standard method, and his payment is to be calculated on the assumption that the first-class man can be taught thus to perform the standard task according to standard methods within standard time. Various false assumptions are made here. It is assumed, indeed Taylor actually states, that "among the various methods.....used in each element of each trade there is always one method.....which is quicker and better than any of the rest" (Sc. M. 25). Certainly there is always one best method of work for every person; but a very little knowledge of the wide individual, mental and bodily differences that exist suffices to appreciate the fact that the best method of work for one person is not necessarily the best method for another person. Even two engines, apparently of the same outward structure, and working under apparently the same external and internal conditions, demand different handling to insure their best output. How much greater must be the difference in the case of two human organisms? Is there one best style of handwriting, of golfing, of violin playing, or is there not a variety—a limited variety, it may be granted—of equally good first-class styles, one or other of which different persons are best fitted to adopt according to their mental and bodily constitution? It is psychologically and physiologically unsound to force a man into one method of work, to train lads in the same mould, on the mistaken assumption that what is best for one is necessarily the best for all. Equally futile is it to take one element out of one man's performance, another element out of a second man's, another out of a third man's performance, because they each seem quick and good, and then by combining them, to expect to reach the quickest and best, composite whole. In the living mind and body, the whole is not the mere sum of its parts. Could one take the healthiest bit of one man, the healthiest bit of a second, third, and fourth, and combine them into a new man, it does not by any means follow that we should make the healthiest individual. An "individual" means an organism which cannot

be divided. One cannot teach him an elementary movement which is best for one person, another elementary movement which is best for another person, and so forth, and expect the total composite movement, formed of those elements, to be the best of all possible movements. What Taylor calls "rigid rules for each motion of every man" (Sc. M. 85) cannot be identical for all men; nor can average rules be prescribed to suit the average man. It is the function of the psychologist, recognising the individual differences of equally good workers, to analyse their different methods, to investigate the mental and physical differences corresponding to those different methods, aud to see that each worker is trained at the outset in the best method to which he is innately best fitted.

Early in the course of his valuable observations in bricklaying, Gilbreth discovered that an expert bricklayer employs quite a different set of movements according as he is working at a fast or at a slow speed. He concluded that a beginner must be taught above all to work at a rapid speed and to pay little or no attention to the quality of his work. To the psychologist this deduction must appear not only unwarranted but probably untrue. Psychological investigations are clearly needed to determine the relation between speed of movements and quality of output which should be observed during training.

Indeed wherever we turn among the recommendations and improvements suggested under early "Scientific" Management, we find the necessity of their being supplemented by psychological and physiological considerations. The human organism cannot be treated as if it were a mere machine. It is impossible to lay down a hard and fast rule (which I have actually seen enforced) that during every hour throughout the day the output shall be a constant fixed amount. In the case of a machine this may be practically possible; but the human worker is affected by accommodation on the one hand, and by fatigue and boredom on the other. The well-known Monday ill-effect (which has been shown to be independent of alcoholic or other dissipation over the week-end) is only an exaggeration of what occurs at the start of every day's work. The operative has first to settle down to his work, to get into his stride and to neglect external distraction. Towards the close of the morning's or afternoon's work, the output is again bound to fall off. Indeed these variations in working capacity at different periods of the day have recently been shown by Muscio to occur quite independently of any previous work; that is to say, they are in part due to a daily physiological rhythm, to hourly fluctuations in the daily wave of efficiency. To demand therefore, the same output at each hour of the working day means to ask too much from the worker at certain hours and too little at others. It means the neglect of certain vital, physiological principles.

Where heavy physical work is being carried out, it is insufficient merely to study the most economical movements by which

it can be performed. The amount of load which the worker can most efficiently lift, and the amount of time during which he should be under load require investigation. I am informed that in this very neighbourhood young boys are to be seen employed in using full-sized shovels. Now Taylor did excellent pioneer work in determining the optimum weight of a fully loaded shovel, and he came to the conclusion that "a first-class man would do his biggest day's work with a shovel load of about 21 pounds" (Sc. M. 65). At that time, the shovellers in the Bethlehem Steel Company's Works, where he was engaged, were using the same sized shovel whether they were dealing with ore or ashes. Hence they were working sometimes "with a load of about 30 pounds per shovel" and sometimes "with a load on the same shovel of less than 4 pounds" (Sc. M. 67). Taylor prudently set to work to construct shovels of different sizes according to the heaviness of the material to be lifted, so that the load might be a constant one of about 21 pounds. They were issued to the workers according to the material they had to handle. The total saving effected by this and other improved organizations, when balanced against the increased cost of tool-room expenses, wages of extra foremen, time-study men, etc., apparently amounted to between £15,000 and £16,000 per annum (Sc. M. 71).

Taylor also did valuable pioneer work in enforcing regular rest periods during heavy manual labour. But, both as regards load and rest periods, a large amount of investigational work yet requires to be done. Such inquiries are beset by numerous pitfalls which can only be avoided by those already trained in psychological and physiological methods. It need hardly be pointed out that a regular rest period has a very different effect from a chance pause owing to delay in the arrival of new materials. Its advantages were well illustrated during the war when trench-digging sections competed against one another for the greatest length of trench that could be dug within a given time. The officer in command of one section allowed his men to dig as hard as they could for as long as they pleased, and then to rest. The officer commanding the rival section divided it into groups, which he so arranged that two groups were always resting, while there was always a third group which was relieved by the other two alternately and was always working. By such arrangement the latter section won easily. Only the other day I was informed how a like scheme had been successfully applied to bottle-making on which teams, each consisting of one man and two boys, were engaged. Three teams were allocated to two machines, and their work was so arranged that one team was always resting for 20 minutes while two teams were working for a 40 minutes' spell. The result was a very considerable increase in the daily output.

Gilbreth was one of the first to draw attention to the waste of effort involved in needless stooping. By arranging the materials

at a convenient height, alike in brick laying and in assembling, he was able to reduce needless fatigue and to increase output enormously. Efficient lighting has been proved not only to increase output but to reduce accidents and breakages. Dim twilight and blinding glare are equally objectionable. They involve all the well-known consequences of eye-strain and fatigue, mental as well as physical. Overcrowding is no less important an error to be avoided. Not only does it lead to needless accidents and breakages; but by perpetuating an atmosphere of discomfort, it inevitably induces a frame of mind in which the operatives cannot possibly be expected to work their best. The same applies to avoidable dust and heat and to deficient ventilation.

I may safely leave you to infer the extent to which these defects call for remedy in the industries with which you are specially familiar. Let us now pass to the consideration of vocational guidance and vocational selection, which in my opinion are likely to turn out to be among the most valuable contributions of applied psychology to industry and commerce. Their objects are to advise the applicant as to the work for which he is innately best fitted, and to avoid the disastrous effects of "round pegs" being placed in "square holes." Vocational *guidance* is applicable to the boy and girl on leaving school or to the worker who is dissatisfied with his occupation and voluntarily asks for examination and advice. Vocational *selection* is applicable to all new-comers in any industrial or commercial concern. The basis of vocational guidance and selection is that for each person there is a most suitable occupation, and that in every occupation there are some that succeed better than others. Through past neglect of these principles the wastage of labour turn-over is enormous. "The number of young persons who thus become engaged in occupations in which they will never do well, the waste of effort on the part of employers in training them to work to which they will never settle down, the waste of years spent in wandering from one occupation to another is little short of appalling." (From a statement issued by the newly established National Institute of Psychology and Physiology applied to Industry and Commerce.) Attempts have (and are still being) made to determine a person's fitness for different occupations by the shape of his head or face, the colour of his eyes or hair, the texture of his skin, the slope of his handwriting, etc.; but I need hardly say that such methods of procedure are devoid of scientific foundation and that no two people employing them will reach the same results. A man's abilities are not correlated with the shape of his brain, nor does the shape of his brain precisely determine the shape of his head. True, a man whose head is below a certain size, or whose facial expression assumes a certain character may almost safely be pronounced an imbecile or an idiot. But beyond this it is hardly possible to go, save in the rough and ready and often wholly erroneous way

in which we are apt to size a man up from his appearance as looking honest, intelligent, persevering, energetic, having a commanding presence, etc., or to size up a horse from its external form. What psychology does is first to ascertain by careful observation and analysis the mental and bodily qualifications needed for a certain job, next to devise tests which are likely to reveal those qualifications, then to test those tests by applying them to *known* good or poor workers at that job and thus to select those tests excellence in the performance of which correlates highly with known efficiency on the job, and to reject tests where such correlation is poor. The tests adopted may be weighted according to their importance, *i.e.*, according to their proved correlation. They are finally applied to persons requiring vocational guidance or selection. The success which has already marked the employment of these methods is little short of astounding. Psychological tests have been employed by our own Navy and Air Service, and on a huge scale by the United States Army during the war. They have been recently introduced into Columbia University, New York, as an alternative to the entrance examinations, the unsatisfactory nature of which is generally recognized. They have been employed for selecting those girls who have the quickest reactions and the best powers of observation in the process of detecting defective bicycle balls; they have been devised for selecting the motor drivers of trams, who can speedily apprehend and act on a suddenly given situation; they have been employed for selecting telephone operators who have acute hearing, clear speech, good memory for figures, quick and accurate reactions to given signals; they have been applied also to assemblers, machinists, clerks, typists, etc. They have been used for selecting operatives who are best fitted to undergo a course of intensive training, with the result that their ranking, in accordance with the knowledge afforded by the tests, correlated very poorly with the *original* estimate of their capacity by the foreman who had been in charge of them, but correlated extremely highly with that foreman's estimate when he had become more intimately acquainted with the men during their subsequent course of instruction.

In conclusion let me say that by the title of my paper it must not be supposed that I decry unduly the great contribution which "Scientific" Management has made to the improved organization of Industry and Commerce. The purpose of my paper has been to point out that, without the co-operation and guidance of men trained in the principles of psychology and physiology, the innovations advocated by the engineering or other technical expert are fraught with great danger and are liable to lead to disastrous results. "Scientific" Management needs to be assisted and safeguarded by "Psychological" Management.

DISCUSSION,

SIR WM. J. JONES:—The lecture to me has been intensely interesting, and it has occurred to me that probably the efforts at selection which Dr. Myers suggested should be made in a psychological manner might, in the first instance, be directed towards trade union leaders, so that by a process of psychology we might get men selected as leaders of the union movement who would so influence the workers of the country that they would be amenable to psychological reasoning. If that were done, I think we should be getting a very long way towards the selection of the fittest people for the particular jobs that have to be carried out.

We have all been extremely interested in the subject, and I would be pleased now for anyone desirous of so doing to take part in the discussion, and to give us the benefit of his views.

MR. SPEIRS:—I have much pleasure in moving a vote of thanks to Dr. Myers for his address. We have spent many hours discussing raw materials, but I am inclined to think that the man who is working that material is, after all, of greater importance. He is raw material too, but far more complex. It is of the greatest importance that one should know all about the men whom one employs, and how to get the best that is possible out of them. The successful man in business to-day is the man who shows an aptitude to pick the right man for the right job. I am afraid, however, that it is a gift, and cannot be determined by this or that scientific method of doing things.

MR. J. P. LEATHER:—I would like to associate myself with the vote of thanks to Dr. Myers, for I have been much impressed with the scientific way in which he has suggested that we should bring the psychological idea into our work. I do not know quite how we are going to apply Dr. Myers' suggestions; at the same time it has been very interesting to hear them. For one thing, Dr. Myers has said nothing as to how to get rid of all the difficulties that there are at the present time in regard to the question of wages, and how we are really to convince the workman that we simply want him to do fair and good work for the money we pay him. Although it seems a simple question it is really very complex. The human element is very much more complicated than the raw materials which, from time to time, we talk so much about.

PROF. H. E. ARMSTRONG:—Dr. Myers has given us a paper that has not only been practical but by implication scientific—not merely psychological and I must take exception to the unfortunate antithesis that is involved in the title and to the sense in which he has throughout used the word "scientific." Stones are always being thrown at "science," and here is another one; at least we should not aim at ourselves. Whoever is scientific acts with knowledge and wisdom, and that is just what Dr. Myers

is asking us to do. Psychology is not worth consideration if it be not scientific in its methods; all through the paper the one claim he made is that we should be scientific in our dealings with workmen. The title Dr. Myers might have used, I think, is "Scientific versus *American* Management"; he is criticising an American proposal: anyway I hope that in this detail the paper will be revised. We have always to be careful, before introducing anything from America, to consider how very different American methods are from ours, how Americans differ from us in temperament. Nothing struck me more on the occasion of my first visit to America than the attitude of labour in the States, the way in which the native-born, *free* American would not soil his hands in doing any real manual work—with a shovel or anything of that kind. The gas pipes were all laid in the streets by imported labour—never by an American—through a system of white slavery. I observed that the free born American, whilst not prepared to tackle such jobs as these, was willing to stand over a machine and to get all the work out of the machine that he possibly could. It was quite astonishing to me to notice the way in which he was ready to get the last ounce even out of himself, *through the machine*, although he was not prepared to tackle hard work in the ordinary sense of that term. I am told, however, that this attitude is now changing. It may be or it may not. Then again, one is struck on going to the States by the extreme docility of the people. They come near to the Germans in that respect. Someone wearing an official badge has only to hold up his finger, and there is complete obedience at once. No one has a word to say. It is that kind of difference which makes it possible to do certain things in America which you could not possibly do over here in England. I must say also that it seems to me that we shall be introducing a rather dangerous system if we make the suggested use of psychology in the choice of everybody for his job. I expect too, that if for instance, those in this room had been put through such a process, not many would have been chosen for the study of refractories. The time factor in development has, I think, also been overlooked. Those of us who have had to deal with young fellows, who have watched them through a series of years and noted their progress afterwards, have learned a good deal. I myself have learned that it is never safe to write an Englishman down as a failure. He may possibly be one for quite a long time but when he gets his chance, he may come out in a remarkable way. I have had two or three students who struck me as being about the "bornest fools" possible. Contrary to my advice and that of their parents they have stuck to their job and these men have, in the course of time, come out well on top. I think the psychologists will have to go back to school to learn a great deal more before they can pronounce judgment in the rapid and dogmatic way suggested. It is quite clear that you may select men on the basis of certain qualities

that may be those chiefly required in connection with special jobs but choice for careers in life is another matter. As I understand it, Dr. Myers' paper, from beginning to end, is a claim to introduce *scientific method* into management; therefore, in all seriousness, I say "Do let us have the title altered to conform with the scientific trend of the paper."

Col. C. W. Thomas:—I must confess that I am thoroughly in accord with the views of the last speaker, because my idea of what I have always understood by the term "scientific" management, does not square with the numerous extracts from Taylor's work that Dr. Myers has quoted. We have to remember that Taylor's work was done a long time ago. There has been quite a lot done in the direction of scientific management since—work which has left Taylor a long way behind. A very great deal has been done on much the lines that Dr. Myers himself has advocated, although it has not been described in the same way. The methods to which he has referred have been evolved to a great extent during the war, and have undoubtedly carried scientific management beyond the stage at which it stood before the war broke out. To condemn scientific management (so-called) on the basis of Taylor's somewhat drastic laying down of the law is, not altogether justifiable. My idea of scientific management is that you should use the best knowledge and the best experience that you can bring to bear upon your subject, no matter whether you are dealing with a man or a machine. If you are dealing with a man you cannot, of course, deal with him in quite the same way as you would when dealing with a machine. I quite agree with Dr. Myers that in this respect Taylor made a mistake; but men subsequent to Taylor have not made that mistake in anything like the same degree. The importance of the subject is very much greater now than when I had a few words to say before the Society a year or two ago. The conditions have changed in many ways; but I cannot see any way in which the importance of scientific management in industry has become less. To my mind it is infinitely more important than it was two years ago, and if I read the signs of the times correctly it is going to be more important still in the future. The broad lines that Dr. Myers has indicated are, quite sound, but I should think they would be a little difficult to carry out in the case of many industries. It is quite possible that they would be much easier in the case of a highly complex industry than in the case of a small and simple one, though I am not at all sure that the need is not greater, at the present time, in the case of the simple industry, than in the case of the more complex one. I hope that Dr. Myers may see his way to comply with the request of the last speaker, and modify to some extent the title of his paper, because I do think it conveys rather a wrong idea.

Dr. C. S. Myers:—I appreciate very much indeed the vote

of thanks which you have so unanimously and cordially passed. It was a very great pleasure for me to come here, and I thank your Secretary for having invited me. The criticisms that have been passed on the paper may be summarised under two heads: (1) the title of the paper; (2) the possibilities of vocational guidance. With regard to the title of the paper, I am going to lay the blame, as one so often does, upon the printer, because, in the title of the paper as I sent it to Dr. Mellor the word "Scientific" appeared in inverted commas. These have fallen out in the rough proofs that you have before you. If that had not been the case probably Prof. Armstrong's criticisms would hardly have been made. I do not complain of scientific management: what I wish to urge is that it requires yet the co-operation of the psychologist to make it *thoroughly* scientific, and that is what I intended to convey. The term "scientific management" was invented by Taylor, and in this country is used by those who worship Taylor as a hero and who look upon his edicts as gospel truth. I think if you will agree to use the word so as to include all the improvements that psychology has added—and as I said in my paper a good deal of progress has been made in America lately owing to the introduction into the factories of people trained in psychology and physiology—then you have allayed my fears.

Dr. Armstrong raised the point that there are difficulties in selecting people for certain jobs on the ground that you do not know for certain into what they are going to develop; and he raises the point as to how many of you would be here to-day if you had been selected by psychological methods. Presumably you have all been examined or selected at some time or other, and I suppose that it really makes no difference, save in degree of efficiency, whether you are tested by methods which are scientific or by those which are merely opportunist or intuitive; I do not agree at all with the opinion that vocational selection is going to rule out a large number of really suitable people. With regard to the argument that a man may be a "duffer" to-day and develop into a very able man in 20 years' time, I do not see how this sort of people would suffer more under a psychological method of selection than under any other. These psychological tests, or a large number of them, are carried out individually, and if you are going to apply these tests mechanically and *en masse* to the higher qualities you are going to make a big mistake. I should be sorry if you went away from this meeting with the idea that the testing is to be done in a prosaic and mechanical way without taking into account the general idea of the character which one forms of the candidate by the way in which he performs the tests, and by his replies to various specific questions that you may put to him. Tests such as you might apply for manual dexterity could not, for instance, be applied for such higher qualities as loyalty, perseverance, leadership and so on, although you might learn a good deal from the way

in which a man applies himself to a test as to his other qualities.

With regard to the question that was raised as to how to get our workmen to do an honest day's work. The psychologist would set about this by getting to know the man, and to discover the reasons for his alleged slackness. There may be a variety of reasons; a man may be innately lazy and under no circumstances capable of doing an honest day's work; or he may have "a bone to pick" with someone—he may be discontented and dissatisfied. A great deal may sometimes be done on a works in the direction of removing the dissatisfaction which is due to ignorance. But I must not make a longer reply. I would like to say in conclusion that although the scheme that I have outlined to you may appear to some of you as impracticable or unnecessarily intricate, in its application it is surprisingly easy, and has been carried out with surprising success, considering the youthfulness of the movement.

Mr. P. Bailey—(communicated): I was present on Wednesday last at the lecture entitled "Psychological versus Scientific Management" given by Dr. C. S. Myers, and thinking over the subject later with more leisure than was possible at the meeting, I would like to put a concrete case before him as an example of the problems we have to deal with in the Potteries.

Some few weeks ago there happened to be in the district a Football Match of more than usual interest, and the whole of our Glost Placers politely informed us during the morning that they intended to stay away from work in the afternoon to see the said match (this was a Monday afternoon). We were at that time, and in fact still are, very short of coal, and the oven in which these men were placing was already two days late in being set in, with the result that the Biscuit Warehouse, the Decorating Shops and the Dipping House were all full of ware waiting to be dealt with by the Glost Placers.

I interviewed them personally, and explained in a perfectly reasonable manner that if they did not work on that particular afternoon the whole of the workpeople employed in the aforesaid departments would have to loose a day's work. The number of people affected was about 50, and the Glost placers fully realised that their afternoon at the Football Match meant the loss of a day's wages to the whole 50.

I think I am possessed of a fair amount of tact in dealing with workpeople, and in this case I actually *pleaded* that these men should at least consider their fellow workers even if they had no interest in keeping up the output of the factory, which, by the way, deals almost exclusively with export trade. However, all arguments were useless, and the men went to the Football Match, and most employers will agree that such lack of consideration for other people is a common occurrence. I should be very much obliged to have Dr. Myer's advice on how to deal with a case like this either Psychologically, Scientifically, or in any other way.

With regard to his remarks about "Round Pegs in Square Holes." I should like to point out that the average man has very little chance of ever being anything else. The majority of men work, not because they like it, but to gain a living for themselves and families, and the wherewithal to spend on the enjoyment of whatever leisure hours they can get.

I grant that there are some who regard life and work as a school for the building of character, and a training ground for a better world to come, and others who take a positive joy in their particular work for its own sake. Such men are, however, few in number and greatly to be envied if they can find, in work, both a pleasure and a means of livelihood.

Very few boys on leaving school have any definite idea as to the walk in life they would choose if they had the chance, and they very naturally choose the one with the most money attached to it. If, later on, they find themselves "Round Pegs in Square Holes" it is almost impossible for them to find "Round Holes!" or in other words, to find work which they can really like, and which would bring them in enough money to satisfy the hungry mouths at home. It is doubtful if any man is always satisfied with his own particular job, and there must be times when he experiences vague regrets for what might have been, and thinks he might have done better in some other sphere. Finally, it has been said that the ideal of the average working-man of to-day is "the acquisition of the highest possible wages for the least possible work in the shortest possible time," and if Dr. Myers can evolve any method of persuading a man to take a pride in his work and at the same time produce as much of it as possible for the benefit of the community at large he will indeed be a public benefactor.

Dr. C. S. Myers:—I feel it impossible to answer your specific questions without hearing what the men have to say on their side. On the face of it, the situation argues a bad atmosphere existing in the works, and one that cannot be remedied by merely tackling this particular incident of the football match. The state of affairs seems comparable to a regiment lacking in *esprit de corps* and loyalty. One knows well what years of work are necessary to remedy such conditions. Selfishness is apt to prevail in all states of society. How many people of education would attend a charity committee meeting on an evening when some first-rate orchestral or theatrical performance proved a counter attraction?

A man will only "take a pride in his work" when he is interested in it. Efforts must be made to induce boys on leaving school not to choose the often highly rewarded blind-alley occupations or the occupations for which they are really unsuited. A "*non possumus*" attitude, because the difficulties are enormous, is indispensible. A man will do his best at his work when he has sufficient incentive. It is the duty of the psychologist to discover, or to press for the adoption of, adequate incentives.

XIII.—Contraction of Some Quaternary Mixtures Fired to Different Temperatures.

COMMUNICATION FROM THE CLAY AND POTTERY LABORATORY, STOKE-ON-TRENT.—No. 97.

By H. S. NEWMAN.

AS was suggested in the original paper on this subject[1] a set of trials has been prepared according to the proposed tables of mixtures.

The results obtained and observations which may be made therefrom will no doubt be of interest to some: also there is something to be learned from them, therefore, they are presented herewith. In order to determine exactly what the various slabs consisted of and also further, to compare the results herein obtained with those obtained by Truss and Stanway[2] all the materials used were subjected to an ultimate analysis. These analyses are as follows:—

	Ball Clay	China Clay	Stone	Flint
Silica, SiO_2	49·18	47·56	71·28	96·10
Titanic Oxide, TiO_2 ..	2·77	—	—	—
Alumina, Al_2O_3.. ..	31·70	38·50	16·18	1·18
Ferric Oxide, Fe_2O_3 ..	·98	·62	·93	·32
Magnesia, MgO ..	·58	·03	·46	·08
Lime, CaO	·98	·29	3·93	1·20
Potash, K_2O	2·12	1·32	3·30	·34
Soda, Na_2O	·70	·10	·92	·76
Loss on Ignition ..	10·87	12·02	3·00	·40

The ultimate analyses were calculated into rational analysis and gave:—

	Ball Clay	China Clay	Stone	Flint
Felspar	17·0	8·35	24·2	6·6
Clay Substance ..	72·12	91·17	33·3	—
Quartz	8·16	—	37·1	91·8
Fe_2O_3,CaO & MgO. ..	4·56	·92	4·11	—

The slabs were all made up from the same materials in the same state by weighing out, slopping up and lawning through 120's lawn. To efficiently mix the materials, each lot was passed through the lawn several times. The slop was then poured on to plaster bats, dried to a plastic condition and pressed into slab moulds.

A special gauge was made to ensure correct and uniform marking for contraction purposes. After thoroughly drying, the plastic to dry contractions were taken, then the slabs were fired in sets at five different temperatures, noting the contraction

[1] *Trans. Cer. Soc.*, **17**, 336, 1918.
[2] *ibid* **14**, 173, 1915.

for each temperature. As a check on the firing of each different set Seger Cones and Watkin Heat Recorders were used, also each complete set was fired in one saggar and placed singly on bats.

The slabs which were fired at Cones 1a, 6a and 8 were now dipped half in lead glaze and half in leadless, this giving one slab from each mixture and temperature with each type of glaze. Particular care was taken to ensure all the trials being evenly coated with glaze.

The compositions of the glazes were according to the following formulae:—

Lead Glaze $\left.\begin{array}{l}\cdot 3\ CaO \\ \cdot 3\ (NaK)O_2 \\ \cdot 4\ PbO.\end{array}\right\} \cdot 2Al_2O_3 \left\{\begin{array}{l}2\cdot 5\ SiO_2 \\ \\ \cdot 5\ B_2O_3\end{array}\right.$

Leadless Glaze:—

$\left.\begin{array}{l}\cdot 016\ Mg.O \\ \cdot 7\ CaO \\ \cdot 189\ K_2O \\ \cdot 096\ Na_2O\end{array}\right\} 1\cdot 466\ Al_2O_3 \left\{\begin{array}{l}5\cdot 72\ SiO_2 \\ \\ \\ \cdot 93\ B_2\ O_3\end{array}\right.$

In order to mature the leadless glaze properly it was necessary to fire to Cone 3a, consequently the whole were fired to this temperature. The trials originally fired at Cone 1a in practically all cases showed a further contraction after glost fire at Cone 3a. So as to compare results readily, the contractions, mixtures, temperatures are tabulated in Table 1, which also shows the calculated rational analysis of each slab in order that the positions may be found on the triangular diagram for comparison with Truss and Stanway's results.

Compared with Truss and Stanway's results it is evident that mixtures 1—6 and also 11 and 12 should craze after standing 6 months, but after standing for 12 months they show no sign of crazing. Mixtures 31—36 should, after standing for 6 months, show similar evidence of peeling but here again there is disagreement for after standing for 12 months slabs 35 and 36 are the only ones which tend to peel and these only at the edges. These differences may be due to a higher glost fire than given by Truss and Stanway or to the different way in which the felspar, etc. of the rational analyses is introduced.

Table 1. Shows the mixtures arranged in groups of six according to the stone and flint content which is constant through each group of six. This serves to give us comparisons of the effect of varying the two clays against one another while maintaining the stone-flint percentage constant.

Table 2. Shows a rearrangement of the mixtures also into groups of six, but in this case the clays are constant for the set and it is the flint and stone which vary against one another. From a careful examination of these two tables many interesting features are brought to light through the contraction variations.

It is impossible, within the scope of this paper to discuss all the points—still, a few may be touched upon in order to show that although it fails to cover the same range of application that many graphic methods do, yet there is something to be learned by the use of the method suggested for quaternary mixtures. It will be noticed that in the Cone 11 column there are many blanks, and others have B against them. Those marked B were all bloated and many of the missing ones were unmeasurable, although a full set was not fired.

It was intended to refire the Cone 016 set at Cone 16 and for this reason they were not glazed. The idea was abandoned owing to so many bloating at Cone 11.

The results marked B are not considered in the following comments:—

By comparing the dry contraction with that at Cone 016 it is seen that the latter in the majority of cases is less than the former, thus showing that up to a certain temperature there is an expansion of all bodies, probably due to the liberation of the combined water. This may explain why articles which are tightly packed in a saggar frequently crack in the biscuit fire.

Another interesting feature is that until the proportion of stone and flint falls below 3 to 2 the replacing of ball clay by china clay raises the contraction and after this proportion is passed the reverse action takes place at the Cone 1a temperature.

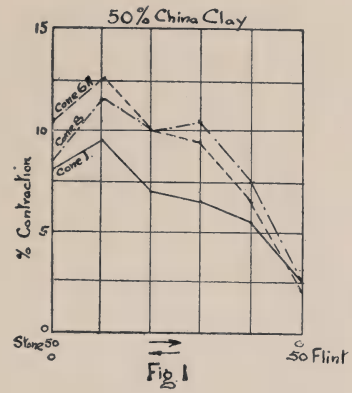
For Cones 6a and 8 the proportion of stone to flint must be below 2 to 3 before the reversion occurs.

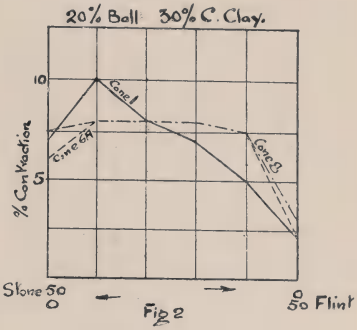
The greatest contraction of all was obtained at Cone 6a in No. 12 mixture which it will be observed contains no ball clay.

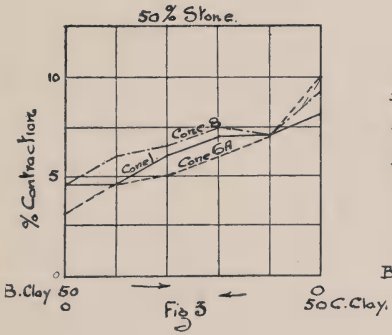
Again, an examination of the contractions with relation to temperatures brings to light the fact that contraction does not always rise with temperature, but, instead, with some mixtures it reaches a maximum and then falls again.

The gradual change from one clay to another, with the other materials remaining constant, does not have a definite rise or fall value on the contraction. Similarly, the change from stone to flint, keeping the clays constant, does not show any direct bearing on the contraction. This is readily shown if the contraction values are plotted as in the following figures. So that any possible variation in the plastic state due to laboratory conditions of preparation shall not effect the curves plotted, the values taken are from dry to fired.

These observations upon the results set forth might be further enlarged but it is hardly necessary to do so as a careful examination of the tables will show, to those interested, the salient features therein contained. The slabs obtained, excepting Nos. 31—36 and also Nos. 1, 2 and perhaps 7 and 13 gave nice close textured bodies mostly vitrifying at Cones 6a, or 8 and they also show that a tremendous variation may be made in the proportions of in-







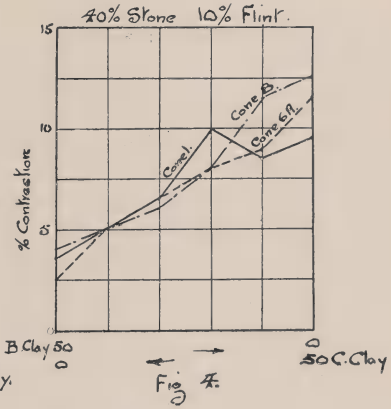


Fig. 1. Shows a graphic representation of the contractions which, for the three firing temperatures shown, are similar.

Fig. 2. Shows the contractions for Nos. 4, 10, 16, 22, 28 and 34 (set 4, Table 2) give quite differently shaped curves for two cones.

Fig. 3 and 4. Both show varying shapes with different temperature. Nos. 1-6 and 7-12 respectively.

gredients used without affecting the working properties or causing crazing or peeling.

It must be borne in mind, of course, that results obtained in laboratory work may be found a little different in factory practice, but there should be a similarity, as practically the only difference in treatment would be the blunging and pugging of the body.

I should like, before concluding this to tender my thanks to Mr. T. G. Simpson, for the valuable help he gave in the preparation of the slabs and subsequent treatment of them.

Table I.

No.	MIXTURE				RATIONAL ANALYSIS			CONTRACTION FROM WET TO					
	B. Clay	C. Clay	Stone	Flint	Clay Sub.	Quartz.	Felspar	Dry	Cone 016	Cone 1a	6a	8	11.
1	50	0	50	0	55	23.4	21.4	5.5	4	10	8.5	10B	9B
2	40	10	50	0	57.6	22.9	20	5.5	4	10	10	11.5	10B
3	30	20	50	0	58.7	21.8	19.6	5	5	11	10	11.5	9.5B
4	20	30	50	0	60.5	20.8	18.6	4	4	11	10	11.5	10B
5	10	40	50	0	62.4	20	17.7	4	4	11	11	11	11,75
6	0	50	50	0	64	19.1	16.7	3·5	4	11.5	14	12	13
7	50	0	40	10	50.5	29.8	19.05	6	4	2.5	8.5	10	—
8	40	10	40	10	51.27	28.2	19.97	5	4	10	10	10	10B
9	30	20	40	10	54.6	27.9	17.11	4	4	10.5	10.5	10	10B
10	20	30	40	10	56.5	26.8	16.24	4	4	14	12	12	—
11	10	40	40	10	59.2	26	15.7	3.5	3	12	14	12.5	11
12	0	50	40	10	59.5	24.8	15.6	3.5	3	13	16	15	15.5
13	50	0	30	20	47.75	34.5	17.5	5	4	10.5	10	10B	—
14	40	10	30	20	49.5	33.7	16.7	5	4.5	10.5	10.5B	—	—
15	30	20	30	20	51.3	32.9	15.7	.5	4.5	12	11	11.5	—
16	20	30	30	20	53.25	31.9	14.85	4	4.5	12	12	12	11
17	10	40	30	20	35	31.2	13.8	4	4	11	14	13	10
18	0	50	30	20	57	30.18	13.05	4	4	11	14	14	—

Table 1—*continued.*

No.	MIXTURE				RATIONAL ANALYSIS			CONTRACTON FROM WET TO					
	B. Clay	C. Clay	Stone	Flint	Clay Sub.	Quartz	Felspar	Dry	Cone 016	Cone 1a	6a	8	11
19	50	0	20	30	44.2	40	15.7	5	4.5	11	10	10B	—
20	40	10	20	30	46	39.3	14.8	5	6	11	11	11	—
21	30	20	20	30	47.6	38.4	13.9	5	5	11.5	12	12B	—
22	20	30	20	30	49.5	37.45	13	4.5	4	11.5	12.5	12.5	—
23	10	40	20	30	51.5	36.5	12.1	4	3.5	10	12.8	13	—
24	0	50	20	30	53.7	35.8	10.3	3.5	2	10	13	14	—
25	50	0	10	20	41.1	45	14	5	5	11	12	11.5	12.5B
26	40	10	10	20	42.1	44.7	13	5	5	11.5	12	11.5	11B
27	30	20	10	20	44	43.7	12.15	5	4	10	11.5	11.5	—
28	20	30	10	20	46	42.7	11.19	4.5	5	9.5	12	12	—
29	10	10	40	20	47.8	49.5	10.3	4	3	9.5	11.5	11.6	—
30	0	50	10	20	49.5	41	9.3	3.5	3.5	9	10	11	—
31	50	0	0	50	37.6	51.3	12.1	5	4	8.5	8	9	—
32	40	10	0	50	38.6	50.1	11.2	5	5	8	9	11	—
33	30	20	0	50	40.6	49.2	10.2	5	4.5	7.5	8.5	8	—
34	20	30	0	50	42.4	48.2	9.3	5	5	7	7	8	—
35	10	40	0	50	44.2	47.4	8.4	4.5	4	6.5	6	7.5	—
36	0	50	0	50	46.1	46.4	7.5	3.5	3	6	5.5	6	—

Table 2.

No.	MIXTURE				RATIONAL ANALYSIS			CONTRACTION FROM WET TO					
	B. Clay	C. Clay	Stone	Flint	Clay Sub.	Quartz	Felspar	Dry	Cone 016	Cone 1a	Cone 6a	Cone 8	Cone 11
1	50	0	50	0	55	23.4	21.4	5.3	4	10	8.5	10B	—
7	50	0	40	10	50.5	29.8	19.05	6	4	9.5	8.5	10	—
13	50	0	30	20	47.75	34.5	17.5	5	4	10.5	10	10B	—
19	50	0	20	30	44.2	40	15.7	5	4.5	11	10	10B	—
25	50	0	10	40	41.1	45	14	5	5	11	12	11.5	12.5B
31	50	0	0	50	37.6	51.3	12.1	5	4	3.5	8	9	—
2	40	10	50	0	57.6	22.9	20	5.5	4	10	10	11.5	10B
8	40	10	40	10	51.27	28.2	19.97	5	4	10	10	10	10B
14	40	10	30	20	49.5	33.7	16.7	5	4.5	10.5	10.5B	—	—
20	40	10	20	30	46	39.3	14.8	5	6	11	11	11	—
26	40	10	10	40	41.1	44.7	13	5	5	11.5	12	11.5	11B
32	40	10	0	50	38.6	50.1	11.2	5	5	8	9	11	—
3	30	20	50	0	58.7	21.8	19.6	5	5	11	10	11.5	9.5B
9	30	20	40	10	54.6	27.9	17.11	4	4	10.5	10.5	10	10B
15	30	20	30	20	51.3	32.9	15.7	5	4.5	12	11	11.5	—
21	30	20	20	,30	47.6	38.4	13.9	5	5	11.5	12	12B	—
27	30	20	10	40	44	43.7	12.15	5	4	10	11.5	11.5	—
33	30	20	0	50	40.6	49.2	10.2	5	4.5	7.5	8.5	8	—

Table 2—continued.

No.	MIXTURE				RATIONAL ANALYSIS			CONTRACTION FROM WET TO					
	B. Clay	C. Clay	Stone	Flint	Clay Sub.	Quartz	Felspar	Dry	Cone 016	Cone Ia	Cone 6a	Cone 8	Cone 11
4	20	30	50	0	60.5	20.8	18.6	4	4	11	10	11.5	10B
10	20	30	40	10	56.5	26.8	16.24	4	4	14	12	12	—
16	20	30	30	20	53.25	31.9	14.85	4	4.5	12	12	12	11
22	20	30	20	30	49.5	37.45	13	4.5	4	11.5	12.5	12.5	—
28	20	30	10	40	46	42.7	11.19	4.5	5	9.5	12	12	—
34	20	30	0	50	42.4	48.2	9.3	5	5	7	7	8	—
5	10	40	50	0	62.4	20	17.7	4	4	11	11	11	11.75
11	10	40	40	10	59.2	26	15.7	3.5	3	12	14	12.5	11
17	10	40	30	20	55	31.2	13.8	4	4	11	14	13	10
23	10	40	20	30	51.5	36.5	12.1	4	3.5	10	12.8	13	—
22	10	40	10	40	47.8	42	10.3	4	3	9.5	11.5	11.5	—
35	10	40	0	30	44.2	47.4	8.4	4.5	4	6.5	6	7.5	—
6	0	50	50	0	64	19.1	16.7	3.5	4	11.5	14	12	13
12	0	50	40	10	59.5	24.8	15.6	3.5	3	13	16	15	15.5
18	0	50	30	20	57	30.18	13.05	4	4	11	14	14	—
24	0	50	20	30	53.7	35.8	10.3	3.5	2	10	13	14	—
30	0	50	10	40	49.5	41	9.3	3.5	3.5	9	10	11	—
36	0	50	0	50	46.1	46.4	7.5	3.5	3	6	5.5	6	—

XIV.—Fused Artificial Sillimanite.

By A. Malinovszky.

THERE is no doubt that the Ceramic industry has been advanced during the last few years. Refractories have been developed to the point where we must now conclude that the most stable and satisfactory products are those which are converted to their crystalline state, whether a single oxide such as Al_2O_3 or SiO_2 or MgO, is used, or whether two different oxides such as Al_2O_3 with SiO_2, or Al_2O_3 with MgO are used. Al_2O_3 is used to some extent, as are also SiO_2 and MgO, which we consider common high refractories, the SiO_2 being converted into tridymite and cristobalite and the MgO into periclase.

The extensive research work and experiments on SiO_2 made by many investigators of ceramic chemistry and by petrologists, lead us to believe that the SiO_2 refractories have been brought almost to perfection. On the MgO refractories also much work has been done, though less than on the SiO_2.

It has been abundantly demonstrated by different investigators, working with Al_2O_3, SiO_2 and MgO, that the conversion of Al_2O_3 to alundum and SiO_2 to tridymite and cristobalite is essential, if we wish to produce a dense refractory with a constant volume, when placed in service under furnace temperatures. MgO undergoes a corresponding change to periclase.

The conversion of SiO_2 into tridymite and cristobalite and MgO into periclase is very sluggish and accomplished only at a prolonged high temperature. Fine grinding of the raw material hastens the conversion process. This is well shown by the calcining of MgO in rotary kilns, where the fine particles are almost all converted into periclase crystals.

We might say that little work has been done on the conversion of the double oxides such as sillimanite Al_2SiO_5 and spinel $MgAl_2O_4$. Many ceramists have tried to mix Al_2O_3 and SiO_2 molecule for molecule to obtain sillimanite, or Al_2O_3 with MgO molecule for molecule to obtain spinel. Theoretically these mixtures represent the composition of sillimanite and spinel crystals perfectly, but in practice, the mixtures are far from having the physical properties of sillimanite or spinel. The products are unstable and cannot be considered as stable crystalline compounds.

No advantage whatsoever can be claimed for uncombined mixtures of Al_2O_3 with SiO_2, or Al_2O_3 with MgO. The real value of such combination is obtained only if the mixtures are fused. Solidifying from such solution the materials develop into their proper crystalline state. The compounds thus formed, sillimanite and spinel are stable. It should be made clear that when we mix Al_2O_3 with SiO_2, or Al_2O_3 with MgO, and expose the mixtures, after they are formed into brick, to a temperature lower than their fusing points

no chemical combination is made, and no crystalline compound is formed, and we do not obtain the desired results. When such a synthetic mixture is made into refractories and placed in service in a furnace where it is exposed to sudden thermal changes, to slag, to alkaline vapours, or to any other destroying elements existing in a commercial furnace, the mixture will be attacked and destroyed by the aforesaid destructive elements.

The suggestion has been made by some ceramist that old glass pots be used, pots in which the free SiO_2 has been dissolved by the alkalies of the glass, leaving behind a magmatic solution from which sillimanite crystals have been separated out after the pots were allowed to cool. The addition of these crystals has no more value in the newly built pots than the common grog has. It stands to reason that if sillimanite crystals produced from such a magmatic solution in the presence of some fluxing agents are not stable, their formation is of no value.

Sillimanite crystals formed under such conditions will be re-dissolved (but not fused) by the chemical activity of the associated substances if heated to a temperature where the adjacent material from which the sillimanite crystals separated out is fused. We should remember that sillimanite crystals are definite compounds, and have definite chemical and optical properties, and therefore should fuse at a definite temperature about 1815°.

More convincing is the fact that sillimanite crystals formed as stated above will be attacked by the surrounding material whenever the temperature at which it becomes liquid is reached. It will then act as a solvent for the sillimanite crystals, and the whole mass will fuse at a temperature lower than the fusing temperature of sillimanite.

We have to believe that a stable compound of sillimanite or spinel is obtained from a mixture of the proper ingredients only when the mixture is brought to the fusing temperature of Al_2O_3 and SiO_2, or Al_2O_3 and MgO. The crystals formation should not be influenced or promoted by any fluxing agent, but only under the influence of the high temperature and by their component oxides, (Al_2O_3 and SiO_2) or (Al_2O_3 and MgO).

Perhaps this will become more clear to us if we consider the property of the components from which the sillimanite crystals are formed. For illustration we may take porcelain bodies containing sillimanite crystals, concerning which many theories have been advanced. Those investigators who came to the conclusion that sillimanite crystals are formed only from an acid liquid, and not from a viscous solution have demonstrated the actual facts. Adding Ca or Mg does not develop the crystals; it only promotes the liquefaction of the magma. If the body or mix should be brought into a liquid state without the addition of Ca or Mg, the crystals would have been developed better.

I am convinced by many experiments which I have made in

this line, that the presence of a high percentage of Ca only retards the development of the sillimanite crystals. Most authors and investigators have laid great emphasis on the importance of felspar as favouring the development of sillimanite crystals, as without felspar no sillimanite crystals seem to be formed in a porcelain body. This statement however, holds good for porcelain bodies, (as the felspar dissolves the kaolin and also the flint) and, I may add, for glass pots and fire bricks. But at the same time, the porcelain only proves my statement that Ca acts as a retarder in the formation of sillimanite crystals. In the glass covering the porcelain bodies, we never see the sillimanite crystals, but close under the glass we see more sillimanite than anywhere else in the same body.

I have demonstrated and am willing to demonstrate again the fact that sillimanite crystals much larger in size (length and diameter) can be produced without the presence of felspar, mica, lime or any other fluxing material, than when these materials are present. It should be borne in mind that if a synthetic mixture such as that of Al_2O_3 and SiO_2 is brought to a boiling temperature, as is the case with my process, it is evident that considerable activity must be present by the molecular dissociations and by the chemical recombinations of the molecules, and also by the molecular attractions and concentration. These facts are very noticable; for instance, if fire clay is used in the process, where the mass is heated up to a temperature of its thermic action. It is well known that the molecules move more freely in a liquid state under the sway of cohesion, by nature's law which causes the molecules to aggregate into chemical combinations and into regular crystals, whenever a magmatic solution is capable of yielding sillimanite crystals. In building up the sillimanite crystals the molecules of Al_2O_3 and SiO_2 must follow their turn in the force of the molecular attraction, becoming regularly arranged groups of molecules in a harmonious vibrating or oscillating relation with one another, and so one molecule after another until the whole magma has been formed into a solid form with a crystalline structure.

We must conceive the theory that at first it must be the union of the two molecules which will create a new molecular compound. This of course will come to us when we try to study the characteristics and the formations of the sillimanite crystals. Then we come to see the inherent relations which exist between Al_2O_3 and SiO_3 whenever sillimanite crystals are formed.

This new process by which artificial sillimanite crystals are produced, consists in reducing aluminous rocks or minerals from one inch in diameter down by smelting in a cupola furnace (which I have specially designed for this purpose) together with a suitable reducing agent in proper amount. It is possible to regulate the volatilization of the silica by proportionating the amount of reducing agent, so that it shall be sufficient to reduce all the silica or to

produce only a fractional reduction of the silica to any desired amounts; leaving only a part of the silica unreduced so to convert all the charge into sillimanite or only a part.

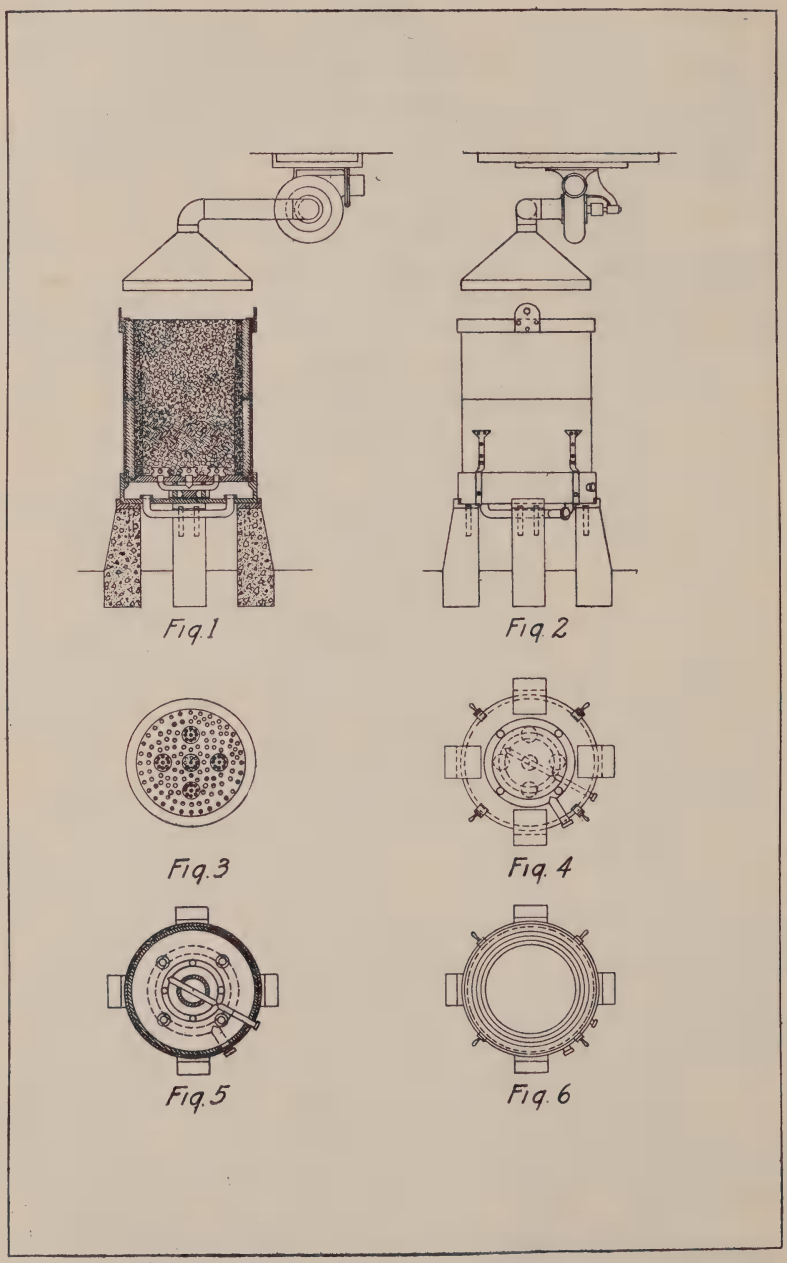
I take for instance the crushed raw materials and mix these with carbon (coke or other material containing carbon) in the molecular proportion to the silica contents in the rock or minerals, as indicated in the following equations:

$$2(Al_2O_3+2SiO_2)+14C=Al_4C_3+4SiC+7CO_2.$$
$$Al_4C_3+4SiC+O_{28}=2Al_2SiO_5+2SiO_2+7CO_2:$$

The proportion of the mixture may however be varied, as an excess of carbon over the calculated amount of silica is sometimes necessary in order to complete the reduction, as the raw material may contain Fe, Ca and others. On the assumption that the above equations are all correct it is then evident that everything present is reduced to carbide, when SiC is formed, and that SiC gives up the C, though not as rapidly as if SiC were alone. It depends on the ratio of the combined carbon and the effect of Si upon the quantity and condition of C. When SiC gives up the C, leaving behind Si, this ignites spontaneously on coming in contact with the blast and forming first SiO, then SiO_2. The attraction between Si+O and then SiO+O is very strong and much heat is produced by the combustion of Si to SiO_2. If Fe is present it usually alloys with the Si, and it is thus that the Si is separated from and volatilized or sunk to the bottom with, the Fe aggregate in globules in the boiling mass, in the form of pure metallic iron.

When fusion commences in the first hot zone, or layer, reaction is taking place, the more Fe, Si, and C are set free; consequently after this first reaction the rest of the reaction takes place more rapidly. It is thus the iron which accumulates, as it is not eliminated from the charge by volatilization. It is very desirable that titanium be present as it prevents the combining of iron with the alumina and therefore the iron can act continuously with the silica when the mass is brought to boiling. It will be seen that the chemical process must go on continuously and consecutively as each thermic zone may permit. This is evident because in two or three hours the temperature has reached the stage where the heaviest fumes of silica emerge and the heaviest deposit of silica takes place. The volatilized silica has a specific gravity, 0·11747 and is snow white as can be easily seen. To bring the whole charge to boiling takes from five to six hours, and the cooling one hour.

Figs. 1—6 represent sections of the furnace. The outside of the furnace is of common iron such as an old boiler shell, or an old smoke stack can be used. This is lined inside with good fire-bricks. The bricks are then protected with a wall about 4 inches thick of the same material which is to be fused, crushed fine. A mould is placed inside the furnace and the raw material is rammed all



Diagrammatic Sections of Furnace.

around between the inside of the furnace and the mould in a tapering shape, as you see it in the figures, to about one inch thick on the top. This will protect the fire bricks from becoming fused and at the same time will also prevent the fused charge from adhering to the firebricks, and so the fused mass can be discharged freely in a very short time. When the ramming is finished the mould is removed. The gratebars, on which big lumps of coke are placed about 30 cm. high, are placed below. These big lumps of coke I prefer to place on the grate bars in order to protect them from fusing. Coke is one of the best solid fuels for my process as it does not crush or disintegrate and carries the weight of the charge better than coal. The coke which has about 44% of air cells has the advantage in preheating the air.

On top of this coke 90 cm. high small coke is placed, then a little kindling wood, on top of this about 40 cm. high small coke again, and the fire is then lighted, the blower being started very slowly until a heavy smoke commences to rise. Then the crushed raw material mixed with the crushed coke is placed in the furnace and the speed of the blower is gradually increased to furnish about 18,000 to 28,000 cu. ft. of compressed air per hour under from 3 to 6 pounds of pressure. The steam commences to rise, mixed with heavy smoke, and in about two hours the charge begins to sink down and the gas to burst into flame above the furnace. The blast of the compressed air is forced through the 160 cm. high fuel bed of coke, becoming very well preheated, and so forced through the hot mass producing combustion.

The deposition of silica is noticed to commence on the furnace wall. This period is very well characterised by the yellow flame coming from the furnace, which then changes to violet and then white. It is very important in this process to have the heat from the bottom of the furnace and therefore enough fuel should be placed to last through the whole process. The furnace must be heated under such a reducing condition in the beginning as to convert gradually all the Al, Si, Fe and others present to carbide. It should be understood that reduction takes place only at those temperatures where solid carbon takes up oxygen from the material. After three or four hours the whole charge is brought to a dazzling white heat, the yellow violet flame indicating the combustion of the Si to SiO and then to SiO_2 and the mass is then at its maximum thermic action.

The mass, or more properly the mixture of alumina and silica, is boiling, which fact is noticed by the roaring noise inside the furnace, and the silica is volatilizing in a dense white bluish, and, finally brownish fumes for about two hours, and after 5 or 6 hours the whole process is completed and the air is blown into the cupola through the fused mass in order to produce cells resembling diatomaceous earth. The specific gravity of this fused mass varies from 2.62 to 2·68. The furnace as you see is provided with an

exit pipe through which the fumes of silica and potash or sodium, if present, and other gases are withdrawn and pass through into a settling system where they are then separated.

From this process it should be clear that it is possible to effect a complete separation between the fused mass, alkalies and also silica, if desired, which is a more economical process than the electric furnace. The hood, as you see, can be removed freely to both sides and also lowered or raised. The hood is suspended above the furnace, and a vacuum is created so as to collect all the fumes, and by this means the cupola is converted into half vacuum furnace, or I may say blast on bottom and vacuum on top.

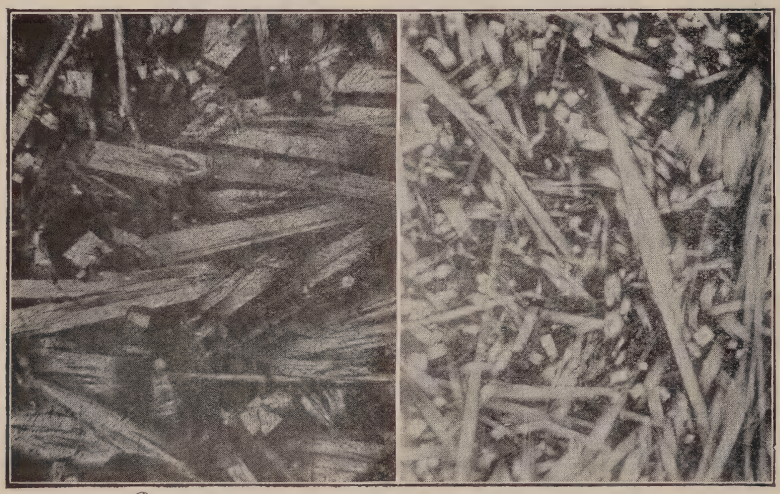


Fig. 7 Fig. 8

Fig. 7. This slide represents the fused sillimanite crystals from the St. Louis fireclay, the magnification is 114 diameters. I have magnified with the purpose to demonstrate that sillimanite crystals are square when cut through the middle. It is very interesting to note the blade shape of the crystals, how they are interwoven, also how these crystals are cut off. It can be clearly seen from the plane of the cut crystals that they are present as long square and parallellogram crystals. The groundmass from which the sillimanite crystals are separated out is uniformly filled with felty needle crystals of fibrous sillimanite. The small crystals are aggregated in radiating clusters with enclosures, in some fields the glass is entirely absent showing only pure sillimanite. I claim that I am the first one to demonstrate that the sillimanite crystals are square, and the first one to demonstrate, or make such large sillimanite crystals.

Fig. 8. Thin section cut from fused sillimanite made from St. Louis fireclay, taken in ordinary light. Note the presence of predominating sillimanite crystals of these constituents. Note also the practical opacity of the glass rendered so by the comparative thickness of the section.

Fig. 9 Fig. 10

Fig. 9. Thin section cut from the fused sillimanite, made from Halloysite; taken in ordinary light. Note the extremely coarse crystals of sillimanite and the globules of opaque material ×25.

Fig. 10. Same as Fig. 9, taken in plane polarized light with crossed nicols.

The fused mass can be removed in different ways, the cupola is so designed as to accommodate varying conditions. The mass can be removed at the bottom with the cupola in place, or the cupola can be removed and leave the fused mass standing in place on the grate bars, or the mass and cupola can be removed, and another cupola, all ready charged, set up on the place, and the operation can begin at once. With this system a continuous process is established. After the fused sillimanite is removed from the furnace it is broken up in a jaw crusher and then reduced to the required fineness, the iron having been separated out by a magnetic device which I have also designed. The fused sillimanite so obtained by this process is a product of a stable compound and of a very high refractory quality, free from expansion and contraction, at any degree of temperature.

This new process by which artificial sillimanite crystals are produced, has also developed a doubt in my mind, that the crystals development is due only to the influence of slow cooling, as I always was taught when I went to school. I suppose that we all have learned that the volcanic rocks which mainly cooled on or near the surface of the earth solidified so quickly that the rocks show very fine and small crystals, or none at all, often with open texture. Obsidian, which is a glassy lava sometimes called volcanic glass, resembles bottle glass, showing no crystal development. It is

composed of about from 65 to 78% of SiO_2, from 12 to 17% of Al_2O_3, the remainder being different oxides of Fe, CaO, etc. The plutonic rocks on the other hand, solidified deep below the surface, had time to cool slowly and to develop a coarsely crystalline structure with a very close texture.

How does this check or correspond with my process, where the mass is brought to the boiling point in from 5 to 6 hours and cooled down in one hour, by a cold blast with 5 pounds pressure, to a porous mass resembling pumice in its appearance, having a coarse crystalline structure with the largest sillimanite crystals ever demonstrated? The micro-photographs demonstrate the different development of sillimanite crystals from different materials. However, in the case of the volcanic glass we might accept the theory that the conditions were not favourable for the promotion of crystallization, as might be the case where the magma was too viscous and chilled too rapidly. Now as demonstrated above, sillimanite crystals can be developed even if the fused mass is quenched in cold water. Then we are also entitled to accept the theory that some other agents have been present which arrested the crystallization process in the volcanic glasses or rocks. This might be the case by virtue of the molecular disarrangements which may have been caused by some physical influence, or the lack of molecular attraction in the subsaturated magma, or by many other factors beside the rapid cooling.

The writer is indebted to Professor Rollin D. Salisbury, Mr. W. Harold Tomlinson and Mr. A. A. Klein, for the valuable assistance in the preparation, examination and reports of the thin sections.

XV.—Note on the Influence of Grog in Admixture with Clay.

By Walter C. Hancock, B.A. (Cantab), F.I.C.

THE general effects of the addition of grog to plastic clays are, of course, well-known and include mainly the reduction of air and fire-shrinkage, increase in the rate of drying, reduction of the tendency to warp, and in many cases reduction of tensile strength and increase in porosity. The extent of the effect on these properties depends not only on the quantity of grog added, but also on the grain size. Some of the effects have been described by S. T. Wilson (Trans. Eng. Cer. Soc., **6**, 121, 1907), and quite recently by F. A. Kirkpatrick (Trans. Amer. Cer. Soc., **19**, 268, 1917).

In the practical work carried out by students in the course on Refractory Materials at the Imperial College of Science and Technology small test-pieces are moulded both from neat clay and from clay admixed with grog, and it seemed there might be some interest in noting some of the results and incidentally any variations between individual workers. The test-pieces for shrinkage, etc., are blocks 10 by 2·5 by 2·5 centimetres (about 4 by 1 by 1 inches) and those for tensile strength are the usual "figure-of-eight" briquettes. The clay—a plastic Stourbridge fireclay—was ground to pass a sieve of 30 meshes to the linear inch and mixed with water until it appeared to be in a proper working condition. After the mass had matured for a time, the test-pieces were moulded and weighed at once, allowed to dry in the air, and then weighed after being heated in a hot air-oven at 105°C. The difference between the weights gives the amount of tempering water and seems the most accurate way of determining this in the case of small test-pieces. The grog used was some of the same clay which had been fired to a high temperature and was thoroughly "shrunk." This was crushed and sieved so that only those particles which passed a one-eighth inch sieve and were retained by a one-sixteenth inch were used, consequently all the fine was rejected in the particular set of experiments under consideration. The mixture used in most of the tests consisted of 20 parts by weight of this graded grog and 80 parts by weight of the clay. The following figures, taken more or less at random, show some results obtained by different observers on neat clay blocks and on blocks composed of 80% clay and 20% grog, graded as above. The percentages of water are calculated on the weights of the blocks after drying at 105°C., and the percentage shrinkages on the original wet lengths, the fire-shrinkages being the total contraction from the wet length after firing to about 1200°C.

Student	NEAT CLAY			CLAY 80% GROG 20%		
	Water	Shrinkage		Water	Shrinkage	
		Air	Fire		Air	Fire
No. 1	19·1	5·6	8·0	18·8	4·0	5·4
No. 2	17·7	5·7	—	15·0	—	—
No. 3	16·8	5·4	7·8	17·0	4·4	4·9
No. 4	18·0	—	—	17·7	—	—
No. 5	18·3	5·5	8·5	16·6	3·0	4·2
No. 6	19·4	5·5	8·1	16·0	4·2	—
No. 7	19·8	5·1	—	15·3	—	—
No. 8	19·0	5·2	8·7	16·5	3·4	5·4
Mean	18·5	5·4	8·2	16·6	3·8	5·0

In the case of the tensile strength briquettes, the corresponding percentages of water were 18·4 in the neat clay and 16·8 in the clay-grog pieces. Though too much reliance cannot be attached to the results, the tensile strengths obtained were:

Unfired Neat Clay	120	lbs./sq.	in.
Fired ,,	960	,,	,,
Unfired Clay-Grog	60	,,	,,
Fired ,,	400	,,	,,

As there was a difference in the amount of tempering water required for the neat clay and for the clay-grog mixture, it appeared there might be some interest in following up this point. Consequently some other series of test-pieces were made up with the object of ascertaining, if possible, how the amount of tempering water varied, first when the percentage of grog of a particular grade was increased, and second when grog of a different grade was used. From these the following figures were obtained:—

	Water per cent.	Shrinkage Air	Shrinkage Fire
Neat Clay	18·5	5·25	8·20
Clay 90%; Grog 10% (1/8-in. —1/16-in.)	17·3	4·47	7·25
,, 80%; ,, 20% (,, — ,,)	16·6	3·33	5·46
,, 70%; ,, 30% (,, — ,,)	15·0	3·08	4·17
,, 80%; ,, 20% (1/16-in.—1/30-in.)	17·5	3·93	6·05
,, 60%; ,, 40% (,, — ,,)	15·9	3·24	3·97

These figures are the mean results of a number of test-pieces in each series, and were all made by the same observer.

From the above table it is clear that the amount of tempering water decreases as the percentage of grog of a particular grade increases, but, as one would naturally expect, the amount of water increases with finer grained grog.

In order to gain some idea of the distribution of the water between the clay and grog in mixtures, it was assumed that if 100

parts of dry clay require 18·5 parts of water to bring the mass into a proper working condition, 90 parts of the same clay would require nine-tenths of this amount, or 16·65 parts of water. Now, from the table above it is seen that in the experiment recorded in the second line the total amount of tempering water is 17·3 per cent. The difference between this and the 16·65 per cent. required by the clay present in the mixture is 0·65, which is presumably attached to the 10 per cent. of grog. On these assumptions 100 parts of this grade of grog would account for 6·5 per cent. of water. Applying this method of calculation to the other series, the following results are obtained:—

				Total Water	Water in clay	Water in grog	Per cent.
1.	Neat Clay	.. ..		18·5	—	—	—
2.	Clay 90%;	Grog 40%	(1/8-in.—1/16-in.)	17·3	16·65	0·65	6·5
3.	,, 80%;	,, 20%	(,, — ,,)	16·6	14·80	1·80	9·0
4.	,, 70%;	,, 30%	(,, — ,,)	15·0	12·95	2·05	6·8
5.	,, 80%;	,, 20%	(1/16-in.—1/30-in.)	17·5	14·8	2·8	13·5
6.	,, 60%;	,, 40%	(,, — ,,)	15·9	11·4	4·8	12·0

The results of these experiments for the coarser grog, though rather divergent, indicate that in this case 100 parts of the grog have about 7 parts of water attached to them, against about 13 parts of water for the finer grog.

On looking over the figures obtained in the course of some other experiments, carried out for quite a different purpose, the results at first sight appeared very contradictory. In these series of experiments, which were all carried out very carefully by the same observer, the same clay and grog were employed, but the latter was separated into the following grades:—

A. Fine. All passed a 30-mesh sieve, but was retained by a 60-mesh.

B. Medium. All passed a 1/16th inch mesh and was retained by a 30-mesh sieve.

C. Coarse. All passed a 1/8th inch mesh and was retained by a 1/16th inch mesh.

This "coarse grog" was the same as that used in all experiments recorded above, except Nos. 5 and 6 in the last table in which the grog was the same as the "medium." The results, calculated as already described, were as follows:—

				Total Water	Water in clay	Water in grog	Per cent.
I.	Neat Clay ..	.. ..	..	18·0	—	—	—
II.	Clay 80%;	Grog, A. 20%	..	21·0	14·4	6·6	33·00
III.	,, 60%;	,, ,, 40%	..	20·0	10·8	9·2	23·00
IV.	,, 80%;	,, B. 20%	..	20·1	14·4	5·7	28·50
V.	,, 60%;	,, ,, 40%	..	18·0	10·8	7·2	18·00
VI.	,, 80%;	,, C. 20%	..	19·4	14·4	5·0	25·00
VII.	,, 60%;	,, ,, 40%	..	14·9	10·8	4·1	10·25

These figures contain the observation that the finer the grog, the more the water attached to it, but the amount of water attached to a particular grade seems to diminish as the ratio of grog to clay increases.

It will be seen at once that there is a considerable discrepancy between these last figures and those given in the previous table, the percentage amounts of water attached to the grog in the latter being much smaller than in the former. The explanation of this, I believe, is that the mass, from which the test-pieces showing the larger amounts of water were made, was far more thoroughly worked and stored for a much longer time before moulding, than the mass from which the test-pieces showing the smaller amounts of water were prepared.

DISCUSSION.

Mr. HANCOCK:—In reply to Dr. Mellor's question, the grog that I was using in these experiments was from exactly the same clay in each case; it had been fired to a very high temperature for us on a works and was thoroughly shrunk. I have not actually determined the amount of the porosity of the grog itself apart from any admixture with clay, but I have assumed that the porosity of the different grades of grog would be the same, seeing that the different grades were all made from the same burnt clay. I quite agree, of course, that this is one of the important points that ought to be considered. My view with regard to the matter was that although the amount of water depends upon the porosity of the grog, the rate at which the grog absorbs the water is dependent to a certain extent upon the time of storage.

With regard to Mr. Ridge's remarks, I take it that when he says he found that after storing for about four days, the material was appreciably dryer, he means the mixture of clay and grog. That would agree with the view that I have taken, that a certain amount of the water finds its way into the grog itself. It is my intention to try some further experiments dealing with the use of a non-absorbent grog to determine how the absorption of the mixture varies then. Experiments will later be made with grog thoroughly soaked, as suggested by Dr. Mellor. I agree that the adhesion between the raw clay on the one hand and the grog itself on the other is enormously increased by thoroughly soaking with the clay. I am not at all sure whether it might not be not only feasible but very likely advantageous for the grog itself to be soaked not merely in water but in a very thin slip of the clay itself.

XVI.—The Analysis of Zirconium Minerals.

By H. V. Thompson, M.A.

During the past few years the technical applications of zirconium and zirconium minerals have greatly increased and consequently several methods have recently been proposed and adopted for the determination of this element in alloys and minerals.[1]

The following investigation has been undertaken with a view to working out a method suitable for the analysis of zirconium ores, zirconium bricks and similar products. Two difficulties are encountered in practice: firstly raw zirconium ores and products manufactured therefrom are not easily opened-up and secondly the separation of aluminium from zirconium is not readily effected.

Opening-up. Zirconium ores are only partially decomposed by fusion with sodium carbonate (with or without the addition of potassium nitrate) or by fusion with potassium bi-sulphate or pyro-sulphate. In either case it is generally necessary, after fusion, extraction and solution of the cake, to filter and again fuse the residue in order to effect the complete decomposition of the material under analysis. The use of a mixture of sodium carbonate and potassium nitrate is not to be recommended on account of its deleterious effect on platinum crucibles. The same objection may be urged against fusion (necessarily prolonged) with bi- or pyro-sulphate, moreover either of these reagents is objectionable for the following reasons: (1) some of the silica is invariably converted into soluble potassium silicate (F. P. Treadwell, *Analyse quantitative*, p. 458, 1912); (2) precipitates formed in the presence of relatively large quantities of alkali sulphates require prolonged washing in order to remove the last trace of sulphates; (3) alkali sulphates inhibit the complete precipitation of hydroxides by ammonium hydroxide (J. W. Mellor, *Quantitative Inorganic Analysis*, p. 180, 1913); and (4) zirconium and potassium form a double sulphate which is readily hydrolysed with the formation of sparingly soluble complex basic zirconium salts (A. Rosenheim and J. Pinsker, *Zeitsch. anorg. Chem.*, **106**, 9, 1919).

A. Travers[1] recommends the use of sodium peroxide and it has been found that this reagent rapidly and completely opens-up zirconium minerals, consequently it has been used in this investigation in preference to all others.

Separation of Aluminium and Zirconium.

It may be of interest to discuss in some detail the various methods which were investigated *viz*: (*a*) precipitation of zirconia in feebly acid solution by *m*-nitrobenzoic acid, (*c.f.* A. C. Neish, *Journ. Amer. Chem. Soc.*, **26**, 780, 1904), salicylic acid (*c.f.* M. Dittrich and S. Freund, *Zeitsch. anorg. Chem.* **56**, 344, 1907), or their ammonium salts. This method is based on the progressive insolubility of the aluminium, iron and zirconium salts of these two acids in solutions of mineral acids but the separation is very delicate and a nice adjustment of acidity is required to obtain reliable results. Moreover, when the amount of ferric oxide is not low, appreciable quantities of iron are co-precipitated with the zirconium, even after a double precipitation; (*b*) the colorimetric determination of alumina by alizarin red (F. W. Atack, *Journ. Soc. Chem. Ind.*, **34**, 936, 1915). This process was found to be useless as zirconia also gives a lake with alizarin red; (*c*) separation of alumina from zirconia by the iodate process (J. T. Davies, *Journ. Amer. Chem. Soc.*, **11**, 26, 1889). The separation is quite satisfactory but it complicates unduly the analysis since it necessitates the previous removal of iron; (*d*) precipitation of zirconia in slightly acid solutions by sodium pyrophosphate (*c.f.* R. J. Carney and E. D. Campbell, *Journ. Amer. Chem. Soc.*, **36**, 1134, 1914). A clean separation was not obtained with this reagent, probably owing to the fact that the acidity of the solution was kept too low, as Nicolardot and Reglade, and Lundell and Knowles[2] have shown that in relatively strong acid solutions zirconium is quantitatively separated from aluminium and iron by secondary ammonium phosphate in large excess. The decrepitation of the zirconium phosphate on ignition is objectionable and washing with cold, 5 per cent. ammonium nitrate solution, as recommended by Lundell and Knowles, is a tedious process where large quantities of precipitate are concerned. Furthermore, there is a discrepancy for the conversion factor to ZrO_2, as given by the two sets of observers, which is a most serious matter when analysing materials with a large zirconia content; (*e*) fusion of the mixed oxides with sodium carbonate and the respective separation of aluminium and iron by digesting the cake, first with water and then with 50 per cent. hydrochloric acid was tried (M. Wunder and B. Jeanneret, *Zeitsch. anal. Chem.*, **50**, 733, 1911). This method is better adapted for the removal of iron and aluminium oxides from zirconia than for gravimetric analysis since it was found that some iron is invariably dissolved by the hydrochloric acid.[3]

Finally it was decided to make use of the fact that after fusion with sodium peroxide and decomposition of the melt with water, the residue contains all the iron, titanium and zirconium oxides, together with some of the silica, while the whole of the alumina and the remainder of the silica is contained in the filtrate. This method was found to work satisfactorily and it possesses the ad-

ditional advantage that the alumina and zirconia are automatically separated during the process of opening-up the sample. Consequently, the subsequent operations are simplified although separate determinations of the silica in the residue and in the filtrate must be made.

NOTE.—Sodium peroxide normally contains traces of silica, aluminium and iron oxides. If the amounts be not negligible a blank determination must be made and corresponding deductions applied to the analytical results.

Analytical Details. 0·5 gm. of the dry (110°C.) *finely* ground sample is heated in a nickel crucible with 6-8 gms. of pure sodium peroxide until a state of quiet fusion is attained. When cool, the crucible is placed in a porcelain basin and a small quantity of cold water added—the basin being covered with a clock glass as the initial reaction is somewhat violent. After the peroxide has been decomposed, the crucible and lid are thoroughly rinsed with water; about 150-200 ccs. of water are added to the contents of the basin and the whole heated to boiling, filtered hot and the residue well washed with hot, 5 per cent. sodium carbonate solution.

"First" Silica. A hole is made in the filter paper and the residue washed through into a porcelain basin; the filter paper is washed with hot, 20 per cent. hydrochloric acid and finally with hot water until free from chlorides—the paper being retained for the silica ignition. About 25 ccs. of concentrated hydrochloric acid are added to the residue, followed by a few ccs. of concentrated nitric acid. The silica is removed from this acid solution in the usual way by a double evaporation to dryness.[4]

Initially the zirconia dissolves completely in the mixture of aqua regia, but during the subsequent evaporations to dryness hydrolysis occurs and the silica contains very appreciable quantities of basic zirconium salts. It is advisable to wash the silica first with hot aqueous hydrochloric acid and then with water. After strong ignition, the silica is evaporated to dryness with a mixture of 4 parts of concentrated sulphuric acid and 9 parts of hydrofluoric acid (*v.* E. Wedekind, *Ber.*, **44**, 1753, 1911) and the residue strongly ignited.

"Second" Silica. The filtrate from the residue, after decomposition of the peroxide fusion, contains, as already stated, part of the silica and the whole of the alumina. The filtrate is acidified with hydrochloric acid and the silica in it determined as in the case of the "first" silica. The sum of the two silicas gives the total silica in the sample.

Iron, Titanium and Zirconium Oxides. The acid filtrate from the "first" silica is heated to 80—90°C., 2—3 gms. of solid ammonium chloride are added, followed by an excess of ammonia. After standing for 5 minutes, the solution is filtered and the precipitate immediately washed four or five times with hot water; a hole is

made in the filter paper and the precipitate washed back into the beaker from which it has just been filtered. The filter paper is then washed with hot aqueous hydrochloric acid and hot water until free from chlorides and kept for ignition. The precipitate is redissolved in a slight excess of concentrated hydrochloric acid (if solution be not complete it is advisable to add a little concentrated nitric acid) and the solution reprecipitated as directed above.

The liquid is filtered into the beaker containing the first filtrate and repeatedly washed with small quantities of a hot alkaline solution of ammonium nitrate[4] until free from chlorides. It has been found that the filtrate from this double precipitation contains inappreciable quantities of zirconia, consequently it is unnecessary to evaporate it to small bulk and again precipitate with ammonia, as in the case of a clay analysis.

The two filter papers containing the ammonia precipitate are transferred to the crucible containing the residue from the "first" silica, and ignited as usual. The ignition, however, must be carried out at a bright red heat until a constant weight is obtained.

After weighing, the ignited oxides are very slowly dissolved in the crucible by fusion with 6—8 gms. of pure fused potassium bisulphate and the fusion continued *until the whole mass becomes pasty*. The cake is extracted, dissolved in dilute sulphuric acid and the solution made up to 250 ccs.

Titanic Oxide. is determined by the usual colorimetric process[4], on 50 ccs. of the solution from the bisulphate fusion.

Ferric Oxide. Raw zirconium ores usually contain notable quantities of ferric oxide, consequently the colorimetric process is not applicable to the determination of iron. Hence an aliquot part of the solution from the bisulphate fusion is reduced with pure zinc and the iron determined by titration with standard potassium permanganate. As the amount of titanic oxide in zirconium ores is relatively low, no great error is made in assuming that in the zinc reduction the whole of the titanic oxide is reduced to the titanous state, hence for every 1 per cent. TiO_2 present a deduction of 1 per cent. Fe_2O_3 must be made from the percentage of ferric oxide as determined by the permanganate titration. If the solution be reduced with ammonium bisulphite or sulphur dioxide[4], the titanic oxide is not affected and the permanganate titration gives directly the amount of ferric oxide present.

The percentage of mixed oxides less the percentages of ferric and titanic oxides gives the percentage of zirconia.

NOTE. Nickel crucibles frequently contain traces of manganese which may be partially co-precipitated with the zirconia if sufficient ammonium salts be not present. If the amount of manganese present be appreciable, it must be removed from the filtrate by adding a few ccs. of bromine water and filtering before the lime and magnesia are determined. Usually zirconium ores

contain only traces of manganese, but if the amount be not negligible, the manganese is determined on a separate sample which has been opened-up by sodium peroxide in a porcelain crucible.[1]

Aluminium Oxide. The filtrate from the second silica is acidified with hydrochloric acid, precipitated by ammonia and the aluminium hydroxide filtered off, washed, ignited and weighed.

Lime and Magnesia. The final filtrates from the respective precipitations of zirconia and alumina are combined and the lime and magnesia determined, as usual, in the filtrate.[4]

The Alkalis are determined by J. Lawrence Smith's process as in a silicate analysis.[4]

Loss of Ignition. The last traces of moisture are often held very tenaciously by zirconium ores, consequently the ignition must be carried out at a bright red heat and prolonged until the loss in weight is constant.

Ferrous Oxide. In some minerals the iron is partly in the ferrous state, probably as ferrous silicate, and if reported as ferric oxide the analysis will be too high by 0·1113 per cent. for every 1 per cent. of ferrous oxide present—an error which, in many cases, is too large to neglect. The accurate determination of ferrous oxide in a mineral is very difficult but the following method, whilst easy to carry out, gives reasonably reliable results:—0.5 gm. of the finely ground material is weighed into a platinum crucible and 10 ccs. of 30 per cent. sulphuric acid added. The crucible, with the lid on, is heated over a very small Bunsen burner—(a micro-burner is preferable)—and when the contents are boiling, 5—6 ccs. of hydrofluoric acid are added. The mixture is boiled for 5—7 minutes and the crucible, lid and contents are dropped into 400 ccs. of cold, freshly boiled distilled water, containing 25 ccs. of 25 per cent. sulphuric acid. The mixture is immediately titrated with standard permanganate until a pink colour, which lasts for at least two seconds, is obtained. (*c.f. Bull. U.S. Geol. Survey*, **422**, 167, 1910).

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[1] A. Travers, *Chimie et Industrie*, **2**, 385, 1919: P. Nicolardot and A. Reglade, *Compt. rend.*, **168**, 348, 1919; *Ann. Chim. anal.* (ii) **1**, 278, 1919. A. R. Powell and W. R. Schoeller, *Analyst*, **44**, 397, 1919: C. M. Johnson, *Chem. and Met. Eng.*, **20**, 523, 1919; G. E. K. Lundell and H. B. Knowles, *Jour. Amer. Chem. Soc.*, **42**, 1439, 1920.

[2] P. Nicolardot and A. Reglade, *loc. cit.*: G. E. F. Lundell and H. B. Knowles, *Journ. Amer. Chem. Soc.*, **41**, 1801, 1919.

[3] *c.f.* L. Weiss and W. Trautmann, *Zeitsch. anal. Chem.*, **51**, 303, 1912: P. Wenger and J. Wuhrmann, *Ann. Chim. anal.*, (ii) **1**, 337, 1919.

[4] *Trans. Cer. Soc.*, **17**, 300, 1918.

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OF

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VOL. XIX.—1919-20.

ABSTRACTS.

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Introduction.

THE following are abstracts from papers connected with the clay, refractories, and glass industries in the more important foreign journals as well as those of our own country. The abstracts are arranged roughly in thirteen classes. The groups are constantly overlapping, and, to avoid repetition, a copious index is appended. This will enable any reference to be quickly found. Most of the journals quoted are permanently filed so that the full papers may usually be consulted by members of the Society. Full translations of any of the foreign papers can be obtained at a small charge. As a rule the abstractor indicates the "subject title" of those articles which, in his opinion, contain either no original matter, or matter not suitable for abstraction.

These abstracts were made possible by a grant from the Joint Committee of Allied Pottery Manufacturers, and were compiled by Mr. J. A. AUDLEY, B.Sc. and Mr. F. SALT (with the exception of a few initialled).

The following particulars respecting patents may be of use to members:—

Country	Address	Co
Britain ..	Patent Office, London	One Shilling (extra postage outside United Kingdom)
United States	Patent Office, Washington ..	Five cents
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In ordering a copy of a patent, the number of the patent and year of the patent, the name of the patentee and the subject of the invention should be stated.

Titles of Journals Abstracted, with Abbreviations.

Amer. Jour. Sci ..... "American Journal of Science" (American)
Amer. Pot. Gaz. ..... "American Pottery Gazette" (American)
Brick ..... "Brick and Clay Record" (American)
Brick Pot. Tr. J. ..... "Brick and Pottery Trades Journal" (British)
Brit. Claywr. ..... "British Clayworker" (British)
Bull. Imp. Inst. ..... "Bulletin of the Imperial Institute" (British)
Cement Eng. News ..... "Cement and Engineering News" (American)
Cer. ..... "La Céramique" (French)
Cer. Vet. ..... "La Ceramica ed il Vetro" (Italian)
Chem. Appar. ..... "Chemische Apparatur" (German)
Chim. Ind. ..... "Chimie et Industrie" (French)
China Rev. ..... "China and Clay Trade Review" (British)
Claywr. ..... "Clayworker" (American)
Deut. Top. Zieg. Ztg. .. "Deutsche Töpfer und Ziegler-Zeitung" (German)
Diamant ..... "Diamant Glas-Industrie Zeitung" (German)
Eng. Ind. Man. ..... "Engineering and Industrial Management" (British)
Faenza ..... "Faenza" (Italian)
Feuerung ..... "Feuerungstechnik" (German)
Giorn. Chim. .... "Giornale di Chimica industriale ed applicata" (Italian)
Glas-Ind. ..... "Die Glas-Industrie" (German)
Ind. Chim. ..... "L'Industrie chimique" (French)
J. Soc. Chem. Ind. .. "Journal of the Society of Chemical Industry" (British)
J. Soc. Glass Tech. .... "Journal of the Society of Glass Technology (British)
Kalk. Schm.-Ztg. ..... "Kalk-, Gips- und Schamotte-Zeitung" (German)
Ker. Rund. ..... "Keramische Rundschau" (German)
Silik. Zeits. ..... "Silikat-Zeitschrift" (German)
Min. Min. ..... "Mines and Minerals" (American)
Monit. Cer. Ver. .. "Moniteur de la Céramique et de la Verrerie" (French)
Pat. J. ..... "The Illustrated Official Journal (Patents) (British)
Porz. Glas. ..... "Die Porzellan and Glashandlung" (German)
Pot. Gaz. ..... "Pottery Gazette" (British)
Pot. Glass ..... "Pottery and Glass" (American)
Pot. Glass Rec. ..... "Pottery and Glass Record" (British)
Prod. Chim. ..... "La Revue des Produits chimiques" (French)
Quarry ..... "Quarry" (British)
Sprech. ..... "Sprechsaal" (German)
Stahl Eis. ..... "Stahl and Eisen" (German)
Tonind. Ztg. ..... "Tonindustrie-Zeitung" (German)
Tonwaar. Ind. ..... Tonwaaren Industrie" (German)
Tonwar. Ofen. Ztg. ..... "Tonwaren-Ofen und Töpfer Zeitung" (German)
Tonwar. Fab. ..... "Tonwarenfabrikant" (German)
TRANS. ..... "Transactions of the Ceramic Society" (British)
Trans. Amer. Cer. Soc. .. "Transactions of the American Ceramic Society" (American)
Zeits. angew. Chem. ..... "Zeitschrift für angewandte Chemie" (German)
Zentr. Bauk. .. "Zentralblatt für Baukeramik and Glasindustrie" (Austrian)

Also a number of other Journals not devoted exclusively to Pottery and Clays.

There is a difficulty in procuring some Continental Journals; and some ceased publication while the war was on.

*** The first number represents the number of the volume, the last the year of publication, and intermediate numbers the page or pages where the subject is discussed.

Abstracts.

I.—RAW MATERIALS.

GEOLOGICAL RESEARCH ON REFRACTORIES DURING 1916.—(*Quarry*, **23**, 10, 1918). Review of "Summary of Progress of the Geological Survey and Museum for 1916," issued by the British Geological Survey.

FIRECLAYS AND GANISTERS OF THE SOUTH OF SCOTLAND. L. W. Hinxman and M. McGregor. (*Quarry*, **23**, **42**, 1918). See TRANS., **17**, 35, 1918.

SILICA ROCKS IN GREAT BRITAIN.—(*Quarry*, **23**, **101**, 1918). Abstracted from Special Reports on the Mineral Resources of Great Britain, Vol. VI. Refractory Materials. By J. Allen Howe.

MAGNESITES AND MAGNESITE BRICKS.—W. Donald (*Pot. Gaz.*, **43**, 296, 1918). See TRANS., **17**, 486, 1918.

MAGNESITE AS RAW MATERIAL.—T. Crook (*Pot. Gaz.*, **43**, 866, 1918). See TRANS., **18**, 67, 1919.

ADVANTAGES OF CLAY STORAGE.—T. H. Riddle (*Claywr.*, **69**, 32, 64, 142, 192, 1918). Reprinted from *Trans. Amer. Cer. Soc.*, **19**, 102, 1917.

USE OF SHALE EXCAVATOR IN CLAY BANK.—(*Claywr.*, **69**, 430, 1918).

ECONOMIC METHODS OF HEATING CLAY STORAGE SHEDS.—C. Hartzell (*Claywr.*, **6**,**9**, 544, 1918). A description of a method that will actually thaw and sufficiently dry clay over night for the next day's grinding. Waste heat from kilns is used, in a way shown in illustrations.

POTASH FROM FELSPAR.—E. A. Ashcroft (*Chemical Trade J.*, **62**, 45, 1918). Discussion on Mr. Ashcroft's paper read before the Institution of Mining and Metallurgy.

POTASH SUPPLIES.—P. G. H. Boswell (*Chemical Trade J.*, **62**, 141, 1918). A brief report of lecture at Liverpool on "The World's Supply of Potash." Correspondence relating thereto appears on pp. 163, 212, 230, 248.

WHITE LEAD.—J. Scott (*Chem. Tr. J.*, **65**, 327, 1919). An illustrated article dealing with microscopical and other features. For effectiveness, white lead should consist of 70 to 75 per cent. lead carbonate and 30 to 25 per cent. lead hydroxide (hydrate). Excess of hydroxide seriously diminishes opacity, whilst deficiency of hydroxide involves loss of binding power coupled with general lack of efficiency as a pigment.

Substances inadvertently incorporated in white lead include metallic lead (giving a greyish tinge), litharge (giving yellowish tinge), red lead (giving rosy tinge), excess of lead hydroxide (giving translucency), and lead acetate or excess of lead carbonate (giving no change in appearance).

Substances intentionally introduced into white lead include barium sulphate, lead sulphate, china clay, chalk, and whitening, but the three last named are very seldom used. On treating a sample of the white lead with dilute nitric acid, all will be dissolved except barium sulphate and lead sulphate (and perhaps china clay). The barium sulphate would be in the form of minute granules which resist the action of any acid; lead sulphate forms needle-shaped crystals.

The author has noticed under the microscope that the precipitation of lead acetate solution by sodium carbonate solution results in the formation of regular networks of extremely minute crystals mostly, whereas with lead nitrate (instead of the acetate) numerous larger individual stellate crystals appear instead of the networks. Both forms may be found when using either solution at times, often with minute separate needles. The stars and needles are heavier than the granules. The interstices between the stars

are gradually filled up until angular objects are formed. The continuous deposition of further particles upon these and upon clusters of less shapely crystals, gives rise to the familiar visible nodules resembling small white seeds.

The author found similar nets, stars, and grains in acetated metallic lead, while it is being converted into white lead. He believes "that the lead hydroxide by occupying positions between the granules, which are nucleated by the stars, holds them together through its affinity for surrounding oxygen without it being able to truly oxidize itself. This idea seems to be confirmed by watching the magnified white lead breaking down under the influence of a dilute acid."

CLAYS OF THE GLASS INDUSTRY.—H. Sch. (*Glas-Ind.*, **29**, 193, 1918). An article dealing briefly with the composition of the clays, their properties (especially refractoriness), and the firing of clays. A paragraph is devoted to the kinds of clays, German and foreign (including Stourbridge and Garnkirk).

FIRE CLAYS OF THE NORTHERN APPALACHIAN COAL BASIN.—E. Lovejoy (*J. Amer. Cer. Soc.*, **2**, 374, 1919). Relates chiefly to flint fire clays in Kentucky, Pennsylvania, Maryland, and Ohio, with a discussion of the physical differences in fireclays—plastic, "semi-hard" and flint-clays.

KLINGENBERG CLAY.—(*Tonind Ztg.*, **42**, 252, 1918). A brief note on the Clay from Klingenberg (near Aschaffenburg in Lower Franconia), which before the war was exclusively used in the United States for making graphite crucibles.

PLASTER.—(*Tonind. Ztg.*, **42**, 344, 1918). A short note. There are three chief kinds of plaster: quick-setting plaster, represented by modelling plaster and plaster of Paris, Estrichgips, and alum plaster or marble cement. The burning temperature is 150-200° C. for the first kind, and 900° C. for Estrichgips (sometimes called flooring plaster). Alum plaster is burned twice. Estrichgips is only used in building (for making floors, etc.).

BELGIAN CLAYS.—B. Juster (*Tonind. Ztg.*, **42**, 377, 1918). A brief discussion.

MICROSCOPIC EXAMINATION OF CLAYS.—R. E. Somers (*J. Wash. Acad. Sci.*, **9**, 113, 1919). Relates chiefly to American Clays. Hydromica is said to be quite abundant in some of the clays examined. The small percentage of potash in many kaolins is considered to belong to mica, as felspar seems to be very scarce. Halloysite was found in only two clays, but rutile in practically all those examined. Some of the clays contained tourmaline, epidote, zircon, titanite, diaspore. For a fuller abstract see *J. Amer. Cer. Soc.*, **2**, 494, 1919.

BAKED SHALE AND SLAG FORMED BY THE BURNING OF COAL BEDS.—G. S. Rogers (*U.S. Geol. Sur., Prof. Paper* 108-A, 1917). See abstract in *J. Amer. Cer. Soc.*, **2**, 495, 1919.

BALL CLAYS OF WEST TENNESSEE.—R. A. Schroeder (*The Resources of Tenn.*, **9**, No. 2, April, 1919). See Abstract in *J. Amer. Cer. Soc.*, **2**, 752, 1919.

MAGNESITE: ITS GEOLOGY, PRODUCTS AND THEIR USES.—C. D. Dolman (*Am. Inst. Min. and Metal Engnrs.*, **152**, 1913, 1919). Relates mainly to American material. See abstract in *J. Amer. Cer. Soc.*, **2**, 753, 1919. Magnesite is now put to many uses, some of which are as follows: refractory porcelains, lining for electric furnaces, composition flooring, stucco, and other oxychloride cements, boiler and steampipe insulation, for the production of magnesium, metal for important new alloys with aluminium and lead, for production of magnesium sulphate, chloride, and hydroxide.

THE MAGNESITE INDUSTRY IN THE UNITED STATES.—W. C. Phalen (*Mining and Sci. Press*, 295, Aug. 30, 1919). Relates to the Magnesite deposits of California and Washington chiefly. See abstract in *J. Amer. Cer. Soc.*, **2**, 907, 1919.

WHITE CLAY POSSIBILITIES OF PENNSYLVANIA.—R. R. Hice (*J. Amer. Cer. Soc.*, **2**, 685, 1919). An illustrated account of the geological occurrence, methods of mining, preparation and uses of certain white clay deposits, with suggestions as to prospecting for other similar deposits. Among the uses specified are in steel manufacture for moulding purposes, and in paper making (mainly as a filler). One such clay, mixed with ground quartzite or ganister, is used for mortar in laying silica bricks. Little (if any) is used in pottery bodies. The contain a high percentage of fluxes, and many contain much fine silica, which should be taken into account in possible use for ceramic purposes.

FIRECLAYS OF THE NORTHERN APPALACHIAN COAL BASIN.—G. H. Ashley (*J. Amer. Cer. Soc.*, **2**, 790, 1919). A discussion of E. Lovejoy's paper bearing this title, p. 374 of the same *J*.

GLASS-SAND RESOURCES OF VIRGINIA.—T. L. Watson (*J. Amer. Cer. Soc.*, **2**, 794, 1919). A general survey, including some analyses.

GEOLOGY OF THE CATSKILL PORTLAND-CEMENT REGION.—R. W. Jones (*J. Amer. Cer. Soc.*, **2**, 870, 1919). A descriptive account, with maps, sections, and other illustrations.

WASHING CLAY.—W. Feldenheimer (*Pat. J.*, No. 1567, 1919). Pat. No. 121,191, Dec. 6, 1917. Relates to a process for cleaning clay by treating an aqueous suspension first in one vessel with a deflocculator, such as weak sodium carbonate, to enable impurities to settle out, and then in another vessel with a flocculator, such as alum solution, which causes the clay to settle, as described in Specification 106,890.

POTASSIUM CHLORIDE.—T. Twynam (*Pat. J.*, *No.* 1573, 1919). Pat. No. 122,048, Jan. 21, 1918. Potassium chloride is obtained by adding a small percentage of sodium chloride with or without the addition of lime or sodium carbonate, to molten blast furnace slag, agitating, and condensing the fumes given off. The amount of potassium chloride obtained may be increased by adding potash bearing minerals, for example felspar or greensand, to the molten slag before or simultaneously with the salt, or to the blast furnace burden.

ALUMINA, ETC.—A Norwegian Firm (*Pat. J.*, *No.* 1575, 1919). Pat. No. 122,623, Nov. 26, 1918. Kaolin, clay marl, halloysite-shale, or the like is calcined at about 500°C., preferably in a reducing atmosphere, and then treated with nitric acid (for instance of 30 per cent. strength), or with nitrogen oxides and steam or water. The aluminium nitrate solution is separated from the residue and treated to obtain alumina, *e.g.*, by calcining or by precipitation with ammonia.

ALUMINA, ETC.—A Norwegian Firm (*Pat. J.*, No. 1588, 1919). Pat. No. 125,578, Dec. 24, 1918. Alumina, and calcium and alkali nitrates are obtained from labradorite or other minerals containing plagioclase by treatment with nitric acid, removing dissolved iron, evaporating to dryness, calcining to about 300°C. to decompose aluminium nitrate, and separating the other nitrates from the alumina by leaching.

ALKALI COMPOUNDS, ETC. FROM SILICATES.—E. Bergve (*Pat. J.*, No. 1593, 1919). Pat. No. 127,566, May 9, 1919. Alkali aluminosilicates, as potash felspar, are decomposed by treating at a high temperature with sulphur vapour or with sulphur vapour mixed with sulphur dioxide. Products termed oxy-sulpho-silicates and sulpho-silicates are stated to be formed by the successive replacement of the oxygen of the potash, alumina, and silica, by sulphur as the temperature is raised. These products may be decomposed by water under pressure and at a high temperature to give

solutions of alkali, or they may be decomposed at ordinary temperature and pressure by weak acids.

ALUMINA.—A Norwegian Firm (*Pat. J.*, No. 1615, 1919). Pat. No. 134,531, Oct. 25, 1919. Solutions of aluminium salts obtained by treating labradorite with acids are precipitated with ammonia under pressure, 10-15 atmospheres being mentioned. The alumina is readily separated by filtration, and the ammonium salt solution may be treated in an autoclave with a mineral such as labradorite to produce ammonia for use again. This ammonia may be produced at a pressure slightly greater than that in the precipitation autoclave so that it can be introduced without the use of a pump.

II.—THE PHYSICAL, CHEMICAL, AND OTHER PROPERTIES OF RAW AND FINISHED PRODUCTS. TESTING.

APPARATUS FOR CONTROL OF THE MANUFACTURE OF SILICA BRICKS.—H. Le Chatelier and B. Bogitch (*Revue de Metallurgie*, **15**, 511, 1918). Relates to investigations undertaken through war conditions. The authors concluded that the most important properties of silica bricks are chemical composition, absolute density, mechanical resistance cold, and expansion and mechanical resistance at 1600°C.

For steel furnaces, where the roof attains a temperature of 1700° C., the silica should not in any case go below 95 per cent., and as much as possible not below 97 per cent. For equal weights, the alkalies have greater fluxing effect than lime, lime greater than alumina, and alumina much greater than iron oxide. Practically, lime, alumina, and iron oxide always occur together. Very good bricks contain about 1 per cent. of each, with 97 per cent. silica.

The usual *method of analysis* of silicates by fusion with sodium carbonate or calcium carbonate is not applicable. The determination of the silica gives uncertain results, errors of several hundredths being easily made. Only the method of treatment (of very finely ground material) with hydrofluoric and sulphuric acids is suitable, the silica being calculated by difference. For the current control of a regular manufacture, it suffices even to determine the total weight of sulphates, the relative proportions of the different bases changing little from one day to another. For very good bricks the proportion of sulphates should not exceed 10 per cent. of the weight of the tested brick. Detailed instructions are given for conducting the analysis.

Absolute density is useful for controlling the firing of bricks. Quartz of density 2·65 is transformed by the action of heat into cristobalite of density 2·34, then into tridymite of density 2·27. Well-fired bricks should have a density between 2·30 and 2·40, according to the ease of transformation of the quartz—2·30 for example with the quartz of Messarges, Souvigny (Allier), and 2·40 with the rolled pebbles of the Loire or quartz du Forez and quartzites of Roule, Cherbourg.

The principle of the method used for determining density consists in introducing a given weight of brick into a graduated tube containing a liquid which easily moistens solid bodies (carbon tetrachloride, benzene, or mineral essence), and measuring the alteration of volume resulting from this addition. The graduated tube has an internal diameter of 6 mm, so that one cubic cm. occupies a height of 35 mm, and it is divided into tenths of a cubic cm. The volume of the tube is 5 c.c., and it ends below in a bulb of the same capacity. Each time 8g. of brick powder is used, the volume of which is between 3·30 c.c. for density 2·40 and 3·47 c.c. for a density of 2·30.

The volumes should be measured to 0·01c.c. With much practice the tenths of a c.c. can be divided by the eye into 10 equal parts, but it is much simpler and much more accurate to get it with a small telescope carrying at its focus a divided reticule. The apparatus is regulated so that 10 divisions of the reticule cover one division of the tube. The good working of this telescope demands several precautions. The diameter of the object glass should be very small, about 5 mm., in order that it may do the work of a diaphragm and allow to be seen distinctly together the divisions on the outside of the tube and the central part of the meniscus, which is placed 4 mm. behind. An object glass of 10 cms. focal distance can be placed 20 cms. from the tube, so that it gives the image in true size. The magnification of the eye-piece and the dimensions of the reticule are combined so as to satisfy the condition indicated above on the subject of the division into 10 of the graduation of the tube. Regulation is accomplished by taking the telescope nearer to or further from the tube. The proper distance once found, the support is definitely fixed. A rack and screw mechanism permits of raising and lowering the telescope.

A table is given of density $\delta = P/v$, where $P = 8g$. (weight of materials, uniformly employed), the values ranging from 2.667 down to 2.228, and the corresponding volumes displaced ranging from 3.00 to 3.59 c.c.

The brick powder should be fine enough to enter the tube easily, and above all should no longer include closed cavities filled with air where the liquid would not penetrate. It should not be absolutely impalpable in order to avoid the prevalence of small quantities of air by superficial adherence. A fine material is obtained, with little impalpable, by making frequent siftings in the course of grinding; the authors use the sieve 50 of 324 meshes per sq. cm. It is necessary to continue the grinding skilfully until the whole of the sample has passed the sieve; as the largest parts are the hardest and are composed exclusively of untransformed quartz of higher density. A porcelain mortar can be used for this grinding without inconvenience, as a few hundredths of porcelain does not appreciably modify the densities.

Cold Crushing Strength. A crushing strength of 100 kg. per sq. cm. seems to be the minimum for preventing excessive loss in transport, etc. Some silica bricks are found to have a crushing strength as high as 300 kg. per sq. cm., but 200 kg. may be considered an excellent strength. The method of carrying out the test is described, with illustrations of apparatus.

Tests at 1600°. Destruction of bricks in steel furnaces seems to be connected chiefly with the expansion accompanying the conversion of unaltered quartz into a low density form of silica, and with the lowering of resistance arising from partial fusion due to metallic oxides originally present in the brick or to ferruginous dust.

Expansion by heating increases with rise of temperature, maximum value being attained at temperatures varying between 1500° and 1600°C. according to the nature of the bricks. Afterwards expansion is perceptibly constant for about 100°, then it begins to decrease because of incipient fusion which brings on a contraction by suppressing the pores of the mass. This contraction begins between 1600° and 1700°C. according to the nature of the bricks. By always making trials at 1600°C. the maximum expansion is almost certain to be observed. The temperature of fusion of good silica bricks is between 1730° and 1750°C., that of pure quartz being taken at 1780°C. The inside temperature of the roof of a steel furnace is between 1700°C. and the fusion point of the bricks.

The best temperature for measurement of resistance under load would seem to be 1700°C., but the authors have hitherto made all their trials at 1600°, owing to the difficulty of obtaining higher temperatures. They hope with the aid of a recuperating furnace to be able to work regularly at 1700°C.

The four bodies employed for resisting high temperatures are lime (melts at 2000oC.), magnesia (partially melts and softens at 1700°C.—owing to impurities), silica, and carbon (melts above 3000°C.), the last

being the most refractory substance known.

Corindite or fused bauxite and carborundum have been tried, both agglomerated with 10 per cent. of their weight of kaolin or a very pure aluminous refractory clay. Corindite can only serve for temperatures not much exceeding 1600°C. Carborundum can be employed up to 1800°C. at least. These two materials can also be agglomerated with 5 per cent. of syrupy silicate of soda solution and 5 per cent. of water; this gives them greater strength after simple drying, but on heating the fusibility of corindite is increased and the oxidation of carborundum. A detailed account is given of tests with these materials

For refractory supports, etc., the authors have got the best results from a mixture of 90 parts calcined purified alumina and 5 parts kaolin, the prepared articles being fired at about 1700°C.

The recuperating furnace previously alluded to is described and illustrated.

Factory Tests. For control of the manufacture it is very desirable to apply frequently simple and cheap tests, such as the following:

Fineness. Frequent siftings of the ground quartz mixture used in the manufacture should be made. The proportion of quartz dust passing a sieve of 200 meshes should exceed 25 per cent. Variation of the proportion of impalpable powder is the most frequent cause of irregularity in the actual manufacture of silica bricks.

Compactness. Unequal compression of bricks during the moulding gives them a variable compactness. It results that in use they expand unequally, which tends to exaggerate the dislocation of the roofs. It should be verified by frequent weighings that all the workmen in the same works give the same compactness to their bricks. The most energetic workmen should not strike their bricks more.

Moistening. The proportion of moisture should always be the same, and should be the highest possible compatible with easy moulding. It is determined by weighing the same brick on leaving the mould and after desiccation. This control should be exercised several times a day, as the workmen have a tendency to use mixtures too dry, which are easier to work but do not give such good bricks after firing.

Firing Tests. Besides the usual pyrometric control of firing (cones, etc.) the expansion of a few bricks should be measured, in order to ensure that it shall remain the same at different parts of the kiln, and also in different firings—at least as long as the same raw materials are used. As the moulds have not exactly the same dimensions, a few bricks should be marked, and these should be measured before and after firing. For marking the bricks, chromium oxide may be used, or cobalt aluminate diluted with sodium silicate.

TESTS ON SILICA BRICKS.—Philipon (*Revue de Metallurgie*, **15**, 487, 1918). A report on trials made, at the factory *des Dunes*, on a great number of samples of quartz. It is claimed that the results show the manufacture of silica bricks to be quite easy, and appreciably less costly than "extra-aluminous bricks, and can replace the latter advantageously in most, if not all cases.

The varieties of silica used were: I., white quartz from the *Massif Central*; II., Norman quartz; III., Grit (or sandstone) from Pas-de-Calais; and IV., Amorphous silica from the Allier. Heated rapidly, I breaks into pieces of the size of a walnut, which remain unchanged up to the temperature of fusion; the pebbles of II crack slightly without splintering of the mass; a large piece of III (thrown into a muffle at 800°C.) seems to suffer no alteration; a block of IV splits into a great number of pieces which are themselves reduced into finer fragments. Analysis gave 97·20, 97·00, 93·30, and 97·60 per cent. of silica respectively, 0·78, 1·82, 2·40, and 0·95 alumina respectively, 0·37, 0·60, 0·40, and 0·52 ferric oxide respectively, 0·60, 0·50, 1·00, and 0·80 loss on ignition respectively, with 0·90 lime in I, and 0·28 lime in III., and no magnesia in any. The fusion points were

found to be 1770°C., 1780°C., 1790°C., and 1770°C. respectively (for I, II III, and IV).

Silica bricks should be as refractory as possible; should be as resistant as possible to compression (good English or German bricks have a crushing strength of about 150 kg. per sq. cm.); should easily resist repeated heatings and coolings; and should have low porosity in order to resist penetration by dusts, gases and slags.

A silica brick is formed essentially of a paste or ground mass composed of fine elements, and of large fragments of silica cemented by the ground mass.

The results of the tests are represented in tables, curves, and other illustrations. The chief conclusions arrived at are included in the following:

After drying and firing, the crushing strength of bricks increases with the fineness of grain of the quartz. All the kinds of quartz used, though physically and geologically very different, can give bricks of good crushing strength if they are made extremely fine grained. Expansion generally increases with the size of the grains of the ground mass, and is practically the same for each kind of quartz, when reduced to very fine powder; this expansion is very low (less than ½ per cent.). Hence *any kind of quartz can be used, in the state of flour for making silica bricks, if sufficiently refractory.*

In bricks made of impalpable quartz (fired at 1300°C.) the largest crystals are united in a glass constituted by the impurities of the quartz (chiefly alkalies), and this glass is saturated by silica from the finest crystals of quartz. In this amorphous cement, rare crystals of tridymite occur. When the ground mass of the brick is formed of larger elements, the quantity of glass decreases and the bricks show less and less cohesion.

The crushing resistence of silica bricks is greatest on adding to the ground material the maximum amount of water compatible with a good manufacture without deformation of the brick on removal from the mould. (In the tests the water ranged from 15 to 21 per cent. and the corresponding crushing strength from 12 to 20 kg. after drying, and from 180 to 270 kg. after firing).

After drying, the crushing strength increases with the quantity of lime added. After firing, the crushing strength of bricks with no addition of lime is already very great; it increases with the quantity of lime up to about 1 per cent., remains constant between 1 and 2 per cent., and seems to decrease beyond 2 per cent. The proper proportion of lime is from 1 to 2 per cent. in the flour. Beyond this, it does not add to the strength, but lowers the fusibility.

The firing temperature for silica bricks should rise as the coarseness of the material increases. With an impalpable flour, hardening begins between 800° and 900°C., and is very advanced at 1200°C. With grains of about 0·13 mm., hardening only begins at 1100°C., and is still slight at 1300°C. Silica bricks containing impalpable powder can be easily fired at 1300°C. Bricks formed of coarser meal like that which most millstone grinders or ball grinders give, should, in order to have the same crushing strength, be fired at least to 1450°C.

The floury portion of the material obtained on grinding quartz contains the softest, most impure, and fusible parts of the mineral, as well as proportions of iron (from the machinery) sometimes amounting to 0·5 per cent. Hence not rarely there is a marked difference between the fusion points of the flour and of the quartz. The addition of lime necessary to facilitate moulding and firing lowers the fusion point further. For all these reasons it is natural to make silica bricks with the minimum of flour.

Results of tests indicated that the crushing strength generally increases with the proportion of flour added. Still with even 30 per cent. of flour, the crushing strength is yet superior to that of German silica bricks said to be of first quality.

The author moulded bricks with 90 per cent. grains and 10 per cent. flour; these bricks include 0·4 per cent. of lime. They present certain difficulties (which are not insurmountable) in removing from the moulds,

but behave very well in firing. For bricks made of the same quartz, expansion in firing increases with the proportion of coarse elements. For bricks made exclusively of flour, the expansion is practically nil for all kinds of quartz.

The porosity of bricks varies as the quantity of flour which constitutes the paste.

The density is about 2·33 for bricks with 60 per cent of flour, and 2·43 for bricks with 30 per cent. of flour.

The varieties of quartz, I, II, and III, all give excellent bricks. Silica IV has a tendency to give weaker bricks, especially if the coarser elements consist of grains exceeding 8 mm. These coarser grains can split, and sometimes provoke dislocation of the brick. But in the form of flour this variety of silica gives a plastic part which has none of these disadvantages.

At the factory *des Dunes* the bricks of ordinary manufacture comprise 70 per cent. of coarse grains and 30 per cent. of impalpable flour, with addition of 0·6 per cent. of lime.

After moulding and drying, the bricks are fired sometimes in an intermittent kiln, sometimes in a tunnel kiln. In the latter, bricks were fired in good conditions with 48 hours heating and 40 hours cooling.

It was proved that cracks which affected certain bricks were due, not to sudden heating or cooling, but to shock which they received at the time of pushing the wagons, happening at about 800°C., the temperature of greatest weakness of the bricks. The firing temperature adopted is 1300°C., which suffices to give very strong bricks at a low expenditure of fuel.

The bricks were well tested in steel furnaces with very satisfactory results.

TENTATIVE TEST FOR REFRACTORY MATERIALS UNDER LOAD.—(*Brick*, **52**, 771, 1918). An illustrated description of furnace and loading device, with method of determining resistance to deformation at 25lbs. per sq. in. (1765 kg. per sq. in.).

TESTS FOR REFRACTORIES.—R. M. Howe (*Brick*, **53**, 1063, 1918). A discussion of tests now in vogue, including fusion test, load test, reheating test, chemical analysis, spalling test, slag test, and occasional tests like cold crushing tests, porosity tests, coefficient of expansion tests, etc. Incidentally the earlier and the corrected fusion points of standard cones are given.

OXIDE OF IRON AND LIME IN SILICA BRICKS.—Bied (*Cer.*, **21**, 132, 1918). From *Comptes rend*, **166**, 776, 1918. The iron compound alone does not give agglomeration, as it does not allow the formation of the network of tridymite. It must be associated with lime.

SILICA BRICKS.—H. Le Chatelier (*Quarry*, **23**, 72, 1918). From a paper read before the Société de l'Industrie Minérale. As shown by Philipon, good silica bricks can be produced from a mixture of at least 95 per cent. of silica including 25 per cent. of powder (through No. 200 sieve), and a fair proportion of grains from 1 to 8 mm. diameter. No particular quality of quartz or sand is necessary, but care and forethought should be used throughout, and very careful firing is recommended, or preferably two firings. It is well-known that a good silica brick left in the flue of a furnace where the temperature is 400 to 500°C., will (19 times out of 20) after a time be found broken in several pieces when taken out. Hence precautions are necessary in heating up the furnace. The greatest difficulty afterwards is to prevent sudden rushes of heat which melt the bricks and thus weaken the furnace arch. To maintain steel at 1600°C. (which is necessary for keeping it fluid enough to pour at 1550°C.), the surrounding temperature must be maintained at 1650°C. or higher. The admission of air must be regulated (by the gas producer man) so as to keep the temperature within the narrow limits of 1650° to the softening point of the bricks. Iron oxide and lime (derived from dust) in the brick eventually lower the fusing point.

A good brick should be judged not only by the number of pourings it has stood without needing repair, but also by the care with which the metallurgical operations have been performed. Manufacturer and user are jointly responsible for the durability of a furnace arch.

EFFECT OF HEAT ON KAOLINITE.—*Brick Pot. Tr. J.*, **26**, 4, 1918). A brief note on results of recent work by Sokolov.

INVERSIONS IN SILICA BRICKS.—A. Scott (*Brick Pot. Tr. J.*, **26**, 71, 1918). See TRANS., **17**, 137, 1918.

SOME NEGLECTED PRINCIPLES IN CLAY WORKING.—(*Brick Pot. Tr. J.*, **26**, 87, 107, 136, 1918). A general discussion—intended mainly for non-scientific readers—of subjects such as colloids, adsorption, etc., and their bearing on clay workers' problems.

SILICA BRICKS.—H. Le Chatelier (*Brick Pot. Tr. J.*, **26**, 119, 1918). From paper read before the Société de l'Industrie Minérale. See abstract from *Quarry*.

A NEW SILICA BRICK.—(*Brick Pot. Tr. J.*, **26**, 132, 1918). A note concerning bricks made by the Cleveland Magnesite and Refractory Company, of Eston, which are said to show exceptional strength under load.

REFRACTORY MATERIALS IN GAS WORKS.—J. P. Leather (*Brick Pot. Tr. J.*, **26**, 134, 1918). See TRANS., **17**, 244, 1918.

TESTING HARDNESS OF BRICKS.—(*Brick Pot. Tr. J.*, **26**, 145, 1918). From *Comptes rend*, **166**, 840, 1918.

EFFECTS OF FINE PARTICLES IN POTTERY.—(*Brick Pot. Tr. J.*, **26**, 163, 1918). A brief review of articles by Rieke in *Sprech*, 1918. See TRANS., **18**, Abs., 105, 1919.

SILICA AT HIGH TEMPERATURES.—(*Brick Pot. Tr. J.*, **26**, 167, 1918). Relates to investigations by Ferguson and Merwin. See also TRANS., **18**, Abs., 29, 1919 (The Melting Points of Cristobalite and Tridymite.

SILICA BRICKS FROM OPEN HEARTH FURNACES.—(*Brick Pot. Tr. J.*, **26**, 203, 1918). From E. Rengade's paper in *Comptes rend*, **166**, 779, 1918. See also TRANS., **18**, Abs., 109, 1919.

REFRACTORY PROPERTIES OF MAGNESIA.—(*Pot. Gaz.*, **43**, 318, 1918. A short note on results obtained by Le Chatelier and Bogitch. See TRANS., **17**, 184, 1918.

SILICA BRICKS.—(*Pot. Gaz.*, **43**, 319, 1918). Abstract of paper by Le Chatelier and Bogitch in *Comptes rend*. Lime (2 per cent.) is better than clay as a flux, and it is concluded that the best mixture for silica bricks is 25 per cent. of impalpable quartz powder (0.01 mm.) and 75 per cent. of coarse quartz (max. 5 mm.)

BENDING OF EASY FIRED WARE.—B. Moore (*Pot. Gaz.*, **43**, 393, 1918). See TRANS., **17**, 351, 1918.

SILICA PRODUCTS. I.—RAW MATERIALS.—A. Bigot (*Pot. Gaz.*, **43**, 463, 1918). See also TRANS., **17**, 259, 1918.

STANDARDIZATION OF TESTS FOR REFRACTORY MATERIALS (PART I.).—(*Pot. Gaz.*, **43**, 464, 1918). See also TRANS., **17**, 300, 1918.

CORROSIVE ACTION OF FLUE DUST ON FIREBRICKS.—J. W. Mellor and W. Emery (*Pot. Gaz.*, **43**, 867, 1918). See TRANS., **18**, 230, 1919.

STANDARDIZATION OF TESTS FOR REFRACTORY MATERIALS (PART II).—(*Pot. Gaz.*, **43**, 868, 1918). See TRANS., **18**, 251, 1919.

REFRACTORIES.—(*Claywr.*, **70**, 137, 233, 324, 410, 504, 1918). A series of articles (with illustrations) in which refractories are discused from various aspects. The special topics include structure (with reference

to articles by Kirkpatrick and Mellor respectively), standard tests, silica bricks (Rengade's results, and those of Le Chatelier and Bogitch), and classification of refractories.

VISCOSITY OF BLAST FURNACE SLAG.—A. L. Field (*Trans., Faraday Soc.*, **13**, 3, 1918). The relation of the viscosity of slag to the metallurgy of iron is discussed, and a new method of measuring slag viscosity at high temperatures is described.

STANDARDIZATION OF CHEMICAL STONEWARE.—H. Nielsen and J. R. Garrow (*Chemical Trade J.*, **62**, 157, 179, 225, 399, 1918). Articles supplementary to those in the same vol., pp. 3 and 23—See also TRANS., **17**, Abs., 73, 1918. The present articles relate to pressure vessels, further calculations, inlets and outlets, storage and transport jars, socketed pipes, condensing and reacting towers, and some concluding observations.

Correspondence on the subject appears on pages 31, 57, 72, 93, 120, 229, 272, 289, 305, and 362.

ZIRCONIA AS A REFRACTORY MATERIAL.—(*Chemical Trade J.*, **62**, 284, 1918). Short report of lecture by L. Bradford on "Zirconia, its possibilities in Metallurgy."

PORCELAIN WARE TESTS.—(*Chemical Trade J.*, **62**, 303, 1918). A short note on tests of porcelain laboratory ware, American and European.

RAPID DETERMINATION OF THE CAPACITY OF BLAST FURNACE SLAGS FOR RUPTURING.—A. Guttmann (*Tonind Ztg.*, **42**, 54, 1918). A brief account.

PROPERTIES OF SILICA BRICKS.—H. Le Chatelier and B. Bogitch (*Tonind Ztg.*, **42**, 80, 1918). See TRANS., **17**, 10, 1918.

DENSITY, ETC.—A. G. (*Tonind. Ztg.*, **42**, 138, 1918). A short discussion on density, and porosity.

REFRACTORY PROPERTIES OF MAGNESIA.—(*Tonind. Ztg.*, **42**, 486, 1918). Abstract of paper by Le Chatelier and Bogitch. See TRANS., **17**, 181, 1918.

SILICA PRODUCTS.—(*Tonind. Ztg.*, **42**, 525, 1918). Report of paper by A. Bigot, borrowed from the *Pottery Gazette*. See TRANS., **17**, 259, 1918.

SILICA BRICKS.—(*Tonind. Ztg.*, **42**, 605, 1918). Report of paper by Le Chatelier and Bogitch, from the *Pottery Gazette*. Relates chiefly to strength of various bricks, as affected by size of grain.

THE KOPECKY ELUTRIATING APPARATUS.—R. G. (*Tonind. Ztg.*, **42**, 629, 1918). An illustrated description of apparatus designed by J. Kopecky, which it is claimed combines the advantages of Nöbel's and Schöne's apparatus. The grain sizes are: I. less than 0·01mm., II. 0·01 to 0·05, III. 0·05 to 0·1mm., IV. greater than 0·1 mm., and correspond respectively to the velocities, $v_1 = 0{\cdot}2$ mm., $v_2 = 2$ mm., $v_3 = 7$ mm., the residue in the apparatus forming the grain sizes above 0·1 mm. Each of the velocities or grain sizes corresponds to a cylinder of different diameter with the same quantity of water flowing through. After boiling up with water 50g. of the sample, the portion which passes through a 2 mm. sieve—termed "fine earth"—is carefully poured into the medium-sized of the three cylinders, the residue in the dish being rubbed against the wall of the dish with fingers covered with india rubber, and washed until pure sand remains. The portions washed out are poured into the same cylinder, and the sand is placed in the smaller cylinder, after which the elutriation process is started. Comparative results obtained with the Schöne and Kopecky processes were:

	I.	II.	III.	IV.
Schöne ..	42·97	16·29	5·70	35·04 per cent.
Kopecky ..	43·87	14·26	5·94	35·63 ,,

The rather higher values found by Kopecky are ascribed to the greater flow through of water preventing the clay particles from keeping together.

THE PROGRESS OF VITRIFICATION AND SOLUTION IN SOME PORCELAIN MIXTURES.—A. S. Watts (*J. Amer. Cer. Soc.*, **2**, 400 1919). An account of results obtained from study of a body containing 33 per cent. Canadian felspar, 17 flint, 25 American China Clay, 25 American ball clay, fired to cones 9, 11, and 13, respectively. Microphotographs are given in illustration. At cone 9 the product showed distinctly angular quartz particles, and more or less circular particles of felspar, the larger grains of the latter being filled with fine needles of sillimanite. After firing at cone 11, the quartz particles have lost their corners by solution, and the felspar particles have been completely dissolved, whilst the sillimanite crystals are more numerous and larger. At this temperature the body attained its maximum mechanical strength; it also had a high dielectric strength and was non-absorbent. After firing at cone 13 the quartz grains are completely dissolved on the edges. The rest of the mass has acquired a milky appearance, and the crystals of sillimanite are so clouded by the matrix—throughout the whole of which they appear—that they might easily be overlooked. The dielectric strength has slightly increased but the mechanical strength is slightly less than after firing to cone II. The size of the sillimanite crystals does not increase with rise of temperature—perhaps owing to increased solubility of the clay substance in the matrix, the greater viscosity of which retards crystal development, though the increased solubility of quartz in the felspar should tend to overcome this viscosity.

From results obtained with three special bodies, of which two had each nearly two per cent. of whiting, it appears that the lime does not add to the sillimanite development, though it certainly increases the solution of the quartz grains at any given temperature. The use of soda-felspar instead of potash-felspar causes increase in size of the sillimanite crystals, apparently without increasing the amount of sillimanite. Preliminary fusion of the felspar and calcium flux adds to the fluxing action and tends to increase the size of the sillimanite crystals without materially increasing the quantity of sillimanite; it also aids the solution of the quartz grains.

Solution of quartz in felspar or felspar-lime glass is apparently proportioned to the degree of fusion and the viscosity of the mass. The sillimanite development in a porcelain is evidently the result of a high state of saturation of an alkali-alumina-silicate.

The loss in mechanical strength after firing at cone 13 indicates that while sillimanite is an important constituent, its development is not always evidence of improved physical properties.

APPARATUS FOR STUDYING THE DISSOCIATION OF CARBONATE ROCKS.—G. A. Bole (*J. Amer. Cer. Soc.*, **2**, 410, 1919). An illustrated description of the apparatus and the mode of using it.

LIGHT-WEIGHT CLAY REFRACTORIES.—M. F. Beecher (*J. Amer. Cer. Soc.*, **2**, 336, 1919). Relates to a study of seven kinds of experimental light-weight bricks, compared with five full-weight commercial bricks of different makes.

The light-weight bricks showed up well in resistance to spalling, and in thermal insulation they are practically equal or superior to all but one of the commercial brands; in 5 of the 7 the load-carrying capacity compared very favourably with the commercial bricks.

The porosity is governed by the character of the clays, the amount and size of the grog, and the amount of sawdust added, the more open-burning clays and the more uniformly sized grog making the more porous bricks; sawdust additions (to relatively open-burning clay mixtures) appear to increase porosity in proportion to volume added.

For similar compositions, deformation at high temperatures varies with the porosity or openness. Five of the seven light-weight bricks de-

formed less than the poorest commercial brick.

Spalling seems to bear no relation to specific gravity, porosity, deformation under load, or cold strength, but is distinctly related to thermal insulation. There is no relation between thermal insulation and porosity.

The following further conclusions are drawn: working properties and drying behaviour of a fire clay mixture are affected by additions of sawdust in the same manner as by additions of grog. Between 15 and 20 per cent. of sawdust may be added to mixtures of the type studied without appreciably affecting total shrinkage. Raw kaolin increases the drying and burning shrinkages, but may be used without harm up to about one-third of the plastic clay content. Forty per cent. sawdust is about the practical limit for a workable mixture. At least 45 per cent. of plastic clay (with not more than 15 per cent. kaolin) is necessary for proper working qualities. The weight of the bricks depends largely on amount of combustible material added, but porosity and apparent specific gravity of the clay used is important. About four pounds seems to be the minimum weight for bricks to compete with best firebricks and retain in the mixture working properties good enough for commercial manufacture.

R. L. Clare stated that ground cork was found more reliable than sawdust for making porous light-weight bricks, and gives the composition of the best mixture.

EFFECT OF VARIABLE PRESSURE AND TAR CONTENT ON THE BRIQUETTING OF ALABAMA GRAPHITE.—R. T. Stull and H. G. Schurecht (*J. Amer. Cer. Soc.*, **2**, 391, 1919). An illustrated account of investigations by the authors, the object being to produce from Alabama flake graphite a granular form for use in making crucibles. The results were satisfactory, but not conclusive, as only four crucibles of each kind were tested.

IMPACT TESTS AND POROSITY DETERMINATIONS ON SOME AMERICAN HOTEL CHINA AND SEMI-PORCELAIN PLATES.—H. F. Staley and J. S. Hromatko (*J. Amer. Cer. Soc.*, **2**, 227, 1919). An illustrated account of the tests with tabulated results.

SOME PHYSICAL PROPERTIES OF AMERICAN COMMERCIAL PORCELAIN BODIES.—J. W. Wright and S. I. Sewell (*J. Amer. Cer. Soc.*, **2**, 282, 1919). A report on an investigation undertaken to supply useful data and to facilitate substitution of other materials for some hitherto used. The results are presented in tables and in plotted curves.

The conclusions drawn from the numerical results included the following: The strengths of the bodies in the dried state and the strengths of the fired porcelains show no radical differences. There is no evidence that the crushing strength in the dried state is a criterion of the fired strength. The compressive strength in the fired state of a laboratory trial body containing no lime or magnesia was the lowest of the series (8 in all). The 6 commercial bodies tested were in use for making table ware.

EXPERIMENTS IN DEAD-BURNING DOLOMITE.—H. G. Schurecht (*J. Amer. Cer. Soc.*, **2**, 291, 1919). The experiments were made with some very pure Ohio dolomites which are nearly as refractory as magnesite.

The difficulties met with in the use of calcined dolomite for making refractory products include the following: It does not stand storage well—largely owing to the raw material being too pure before calcination, in which case the lime readily becomes air-slaked. It lacks bond when used in a furnace and therefore has a short life—also owing to the great purity, as the presence of impurities enables it to bond together better.

Reference is made to a number of patents on dead-burning the purer grades of magnesite and dolomite, with or without admixture, or with previous separation of magnesia from lime in dolomites. Several analyses are given.

In the investigation, iron ore, slag, roll-scale, or other impurity was added in various proportions to the dolomite, and the following were among

the results and conclusions: Roll scale seems to be very effective in dead-burning dolomite without unduly decreasing refractoriness. Addition of impurities containing silica caused dusting in the calcined material, due to conversion of β $2CaO,SiO_2$ into γ $2CaO,SiO_2$; this was most noticeable with blast furnace slag or shale added, but also with flue dust, kaolin, or basic open hearth slag, whereas roll scale or iron ore caused least dusting. It was found that 20 to 30 per cent. of iron oxide may be used without bringing the refractoriness of the mixture below cone 31. A mixture of 10 parts kaolin with 20 parts dolomite, has a softening point of cone 31. When dolomite is mixed with tar, packed in graphite, and fired to cone 18, it becomes very resistant to slaking, but if not packed in graphite during burning, it slakes easily. When dolomite is mixed with 10 parts calcium chloride and fired to cone 15 it becomes very resistant to the slaking action of water. Increasing the firing temperature increases resistance of dolomite mixtures to disintegration. Dolomite ground very coarse (4 or 8-mesh) or fine (40-mesh) was found easier to dead-burn than when screened through 20-mesh, but the coarse material, if re-ground, does not resist slaking as well as the 40-mesh material.

INFLUENCE OF PRESSURE ON THE PERMEABILITY OF A ZINC MUFFLE.—O. Muhlhaeuser (*Metall und Erz.*, **16**, 323, 1919). The permeability of the body of a zinc muffle is much affected by the thickness of wall, the kind, number, and size of the pores, and by cracks, holes, and the quality of the glaze of the slag layer. The speed with which a gas passes through a diaphragm is proportional to the difference of pressure on opposite sides; it also depends on the nature of the gas (particularly the specific gravity of the constituents), and on the temperature.

The conditions in a zinc muffle newly set in the furnace are doubtfully similar to those of a diaphragm. Unfortunately it is not possible to ascertain in particular cases the factors which influence the speed, but the action which pressure exerts on permeability can be ascertained without difficulty by measuring the quantity of gas which passes out from the condenser under artificially induced conditions, and determining the nitrogen content of the gas. By measuring the difference of pressure, either the pressure in the muffle or that in the furnace can be increased as desired.

With older vessels the conditions are complicated by the presence of the enveloping skin of silicate (glaze and slag-layer) as well as cracks. Thus in the new muffle the passage of gas proceeds more from molecular diffusion movement, whilst in older muffles it is more of a mass movement.

Reduction of pressure in the zinc furnace is caused by simply drawing the smoke gas damper, and increase of pressure in the muffle is produced by dipping into water a gas outlet tube having a gas-tight connection with the condenser. The author devised methods for measuring the gases passing off from the condenser and for determining of the nitrogen in the muffle gases.

As already reported in the same journal (p. 191, 1919), under normal circumstances excess of pressure prevails in the whole furnace (combustion chamber), This excess pressure, though not very great, is sufficient to cause the furnace gases to penetrate into a damaged muffle. The construction of the furnace and the manner of working it are also to be taken into account.

Results of experiments are given in tabulated form, and it was found that as the tension inside the muffle increases, less gas flows to the condenser, and that not only the quantity but also the nitrogen content of the muffle gas in the mass diminishes as the tension in the vessels increases. This is due to the fact that with increase of tension in the muffle less combustion-gas from the furnace enters the interior of the muffle and finally the influx from outside generally desists; moreover, part of the reaction products developing from the charge will escape through the wall of the vessel.

By making tests first under normal working conditions, then after lowering the pressure in the furnace, and finally after adjusting to about

the pressure originally prevailing in the furnace, it was found, as was expected, that the lowering of pressure caused a diminution of the outflow as well as of the nitrogen content of the gas issuing from the condenser, and that after adjusting to the original pressure the quantity of outflow and gas composition changed back again to about their previous values. As a result of contraction and of the formation of the silicate skin on the inner and outer surfaces of the muffle, the permeability of the older muffles decreases day by day towards a minimum value.

Penetration of certain components of the fire gases leads at certain times to the formation of so much more zinc oxide or zinc dust that the vessel or the condenser becomes partly stopped up with it, and the pressure in the distillation apparatus becomes much greater than in the furnace, a process which may be associated with great loss of metal. At certain times the tension in the furnace is as great as, or only little greater than, in the muffle, in which case interdiffusion will take place. But generally it may be assumed that the gas passes mainly through cracks, and only in a minor degree through the pores. The glaze and slag skin are also permeable.

The main results are that: (1) with increasing tension in the muffle the quantity of gas passing out of the condenser decreases, but that which escapes through the wall of the vessel to the furnace chamber increases, and therefore also the loss of metal increases with increase of pressure in the muffle; (2) a zinc furnace should never be held too long under chimney-draught; (3) under otherwise similar circumstances, the permeability of the muffles at the back of the furnace will be greater than that of those in front (where the pressure is correspondingly greater); (4) every zinc furnace should be built so that it can be worked under the highest possible pressure.

APPARATUS FOR WORKS CONTROL.—F. Moser (*Chem. Appar.*, **5**, I., II., 25, 67, 75, 113, 137, 170, 179, 185, 1918). An illustrated account of various contrivances for controlling factory operations. Included are King's pressure gauge, Recknagel's micromanometer, Ochwadt's pressure recorder, Crosley's pressure recorder, Hudler's, Stemmüller's, and Dürr's draught meters, Schultze's and other differential draught meters, Schultze's differential manometer, Fuess' recording vacuum manometer, flat-pen manometer, Bourdon's and other forms of tube pen manometer, Eckardt's recording manometer, micromanometer with bent measuring tube, Berlowitz' micromanometer, water motor, Fuess' recording volumenometer, Eckardt's steam meter, Bayers' steam meter, the Venture tube, Siemens' and Halske's power indicator, Kennedy's water meter, simple float water gauge, Eckardt's pneumatic water gauge, Eckardt's mercury pen thermometer, Fuess' thermograph, Eckardt's graphite thermometer, Heraeus' resistance thermometer, thermoelectric pyrometers (with indicators), the "Chronos" automatic coal weigher, Fuess' automatic temperature regulator, "Ados" and "Okonograph" apparatus for determining CO_2—also Eckardt's and Keiser and Schmidt's, as well as Strache's "Autolysator" and the Dusseldorf "Hydro-Analysator," Simmance and Abady's gas balance, Hydro-Apparatus for specific gravity of gases, Junker's automatic gas calorimeter, etc.

FAILURES OF HIGH TENSION INSULATORS.—E. Parry (*N. Z. J. Science and Tech.*, 286, 1918). A discussion of the cause of failure in porcelain insulators of the "pin" type, etc. The "pin" insulator consists of four separate shells of porcelain about $\frac{1}{2}$ inch thick, cemented together by Portland Cement, which fills the joints between the shells; the innermost shell is fitted with a cast-iron thimble fixed to the shell by Portland cement. The insulator is fastened to the bracket arm by means of a bolt, one end of which is screwed into the thimble and the other end is fitted with a nut and an asbestos washer. The top shell is grooved to receive the transmission-wire, and has also a grooved neck for a clamp which holds the conductor in place. Insulators of this type carried three-phase lines at 66000 volts between phases—nearly the limit voltage; whenever the line voltage ex-

ceeded 80000 volts, it was necessary to employ a different type, consisting of a number of one-shell or two-shell insulators suspended in series one below another; thus a series of six single-shell insulators was commonly used on a 110000 volt circuit, each insulator having a metal cap fixed to the porcelain by Portland cement.

Though at ordinary temperatures an excellent dielectric, porcelain begins to lose its dielectric strength at 100°C., is very poor at 300°C., and at a red heat conducts fairly well. The special factors upon which the life of the insulator depend are: (1) The more or less complete vitrification of the porcelain; (2) The unglazed surface at the cemented joints; (3) The difference in thermal expansion of the porcelain and the iron of the thimble or cap; (4) The continued hydration of the cement, with accompanying expansion. Severe climatic conditions and great variation in temperature seem to cause failure of insulators from different expansion or contraction of the porcelain and the iron cap. A humid climate promotes hydration of the cement (with expansion) at the joints of the insulators. In cases where extremes of temperature and humidity do not exist, failure seems to arise from lack of complete vitrification of the porcelain, moisture being taken up from the cement. Cavities are always present in the cement, and possibly some failures occur through local heating of the cement and transfer of the heat to porcelain. To prevent failures: (1) The interface of the joints should be glazed; (2) Non-porous and non-expanding material should be used for jointing (if Portland cement, the exposed faces should be coated with water-proof varnish); (3) Face of joint between shells should have minimum size and be horizontal.

EFFECT OF TIME AND TEMPERATURE ON THE MICRO-STRUCTURE.—A. B. Peck (*J. Amer. Cer. Soc.*, **2**, 175, 1919). An illustrated account of an investigation of silica-clay-felspar bodies of known composition fired under known conditions of time and temperature, with special reference to the development of sillimanite. The author found that quite dissimilar bodies can be produced by holding porcelain at a constant temperature for lengths of time which lie within the variations of commercial practice, the clay passing into amorphous silica and sillimanite which in turn passes into crystallized sillimanite. Solution of the quartz takes place at the same time. The difference in structure becomes more marked the higher the firing temperature. The longer the firing at a constant temperature, the greater the amount of sillimanite formed, the larger and better developed are the crystals, and the more quartz is dissolved by the felspar. Bodies fired for longer periods at lower temperatures simulate very closely those fired at higher temperatures for shorter periods. Prolonged firing tends to produce increasing amounts of glass and sillimanite, and therefore probably increases the translucency. Sillimanite crystals are produced by a gradual passage from the amorphous to crystalline state without the aid of a flux, or with the aid of felspar as a flux they are formed in well-developed crystals in the felspar glass at kiln temperatures through solution and recrystallization of amorphous sillimanite. It does not appear that the temperature of firing of porcelain bodies can be predicted from a petrographic microscopic study without at least some knowledge of composition and length of firing.

BEHAVIOUR UNDER BRASS FOUNDRY PRACTICE OF CRUCIBLES CONTAINING CEYLON, CANADIAN AND ALABAMA GRAPHITES.—R. T. Stull (*J. Amer. Cer. Soc.*, **2**, 208, 1919). Conclusions drawn from the results of tests included the following: Substitution of Canadian graphite up to 25 per cent. for Ceylon decreased the life of the crucible. Crucibles containing only Canadian graphite gave nearly as good service as those containing 25 per cent. Canadian and 75 per cent. Ceylon. Substitution of Alabama flake graphite or coked Alabama graphite, for the Ceylon improved the crucibles' life. Substitution of coked Alabama graphite for Alabama flake up to 22.73 per cent. increased the life of the crucible and higher

substitutions decreased it., No material advantage was gained by converting Alabama flake graphite to the granular form.

The effects of certain variations in the clay content are also alluded to.

The larger the crucible the larger the graphite grains should be in order to produce a crucible of maximum strength and service.

REFRACTORY MATERIALS AS A FIELD FOR RESEARCH.—E. W. Washburn (*J. Amer. Cer. Soc.*, **2**, 3, 1919). A general discussion, including definition of "Refractory material," U.S. Geol. Survey statistics, a comprehensive hypothetical organization for research (complete and systematic) on refractory materials, statistics, publication and indexing, phase-rule investigations, physical constants, standard tests, standard specifications, financing the research organization, etc.

FUSIBILITY OF GRAPHITE ASH, AND ITS INFLUENCE ON CLAY.—M. C. Booze (*J. Amer. Cer. Soc.*, **2**, 65, 1919). Ceylon graphite contains from 2 to 30 per cent. ash. In a crucible any fluxing action of the ash begins on the surface, where the carbon is first burned away, and such action proceeds inwards only as fast as the ash is formed. Fluxing action would be retarded by the production of a dense skin resulting from the softening of the clay and ash mixture. The results of numerous tests are given in a table.

The author concluded that the softening point of a graphite ash is not a true criterion of its action in a crucible body, that the tendency of graphite ash to lower the refractoriness of a crucible is not evident at brass-melting temperatures and would seldom be detrimental even in steel melting crucibles, and that the ash from Alabama graphite is less effective as a flux than the ashes from Ceylon, Canadian, Pennsylvania or New York graphites.

CLAYS FOR USE IN PAPER-MAKING.—R. B. Roe (*J. Amer. Cer. Soc.*, **2**, 69, 1919). Mineral fillers or loading materials have long been introduced into the suspension of fibres in water which forms the basis of paper. During conversion of this suspension into paper some of the mineral filler is lost, the rest being associated with the fibres in the paper so as to modify its physical characteristics. Without fillers it would be impossible to make a satisfactory paper for many purposes. The filler helps to fill the interstices between the interlaced fibres, and gives a smoother surface as well as opacity, though it reduces the strength of the paper. For coated paper the mineral ingredient mixed with a suitable binder is applied to the surface of the sheet. Filling materials used include clay, calcium sulphate (pearl hardening, crown filler, terra alba, gypsum, etc.), talc, asbestine or agalite, and blanc fixe (or precipitated barium sulphate). For coating, are used chiefly clay, blanc fixe, and satin white, the latter being a mixture of precipitated calcium sulphate and hydrated alumina with more or less calcium hydrate.

Clay is much the most important material used for both loading and coating.

The qualities in clay most important are colour, grit, and retention. A strong white colour is desirable, at any rate for the best qualities of paper, Silicious grit (or sandy material) is very objectionable owing to its wearing action on the fine wire of the paper machine, and for other reasons. Micaceous grit shows up as objectionable shining specks.

Retention means the ratio between the amount of filler used and the amount retained in the paper.

Some American clays have been found suitable as fillers, but none to be satisfactory for coating.

REFRACTORIES IN THE ZINC INDUSTRY.—M. G. Babcock (*J. Amer. Cer. Soc.*, **2**, 81, 1919). A comprehensive survey of the whole ground as far as the manufacture of retorts and condensers is concerned, including the raw materials consisting of plastic fireclays, grog, and coke; high-grade firebricks are also brought under consideration.

DIELECTRIC FAILURE OF PORCELAINS.—C. Treischel (*J. Amer. Cer. Soc.*, **2**, 96, 1919). A discussion of a possible cause of such failure when no mechanical defects are apparent.

It has long been known that when quartz and certain other substances are subjected to pressure on two diametrically opposite faces which are parallel to the major axis, a measurable potential difference is set up, which varies directly as the pressure; this is known as the piezo-electric effect. The converse is also true, that when a potential difference is set up on two opposite faces paralled to the major axis of a crystal, the crystal is subjected to a squeezing action.

Porcelain contains numerous quartz crystals, cemented together by a glassy material consisting largely of fused felspar. When such a structure is exposed to the influence of alternating high potential, many of these quartz crystals probably have their major axes at right angles to the direction of flow of the electric current. The current itself is changing its polarity in accordance with the cyclic change, and during each cyclic change there are points of maximum and zero potential difference—two maximum and two zero potential differences for each cycle. The effect on each crystal with its axis in the right direction will be a vibratory movement parallel to the direction of the flow of the displacement current. This effect might cause breakdown of the dielectric through (1) rupture of the crystals, (2) rupture of the glassy magma surrounding the crystals, and (3) leakage of current through the voids between the crystals and the magma when the crystal is at its greatest deformation and the potential difference is at its maximum.

In course of discussion several writers express doubts concerning the proposed explanation. The author claims that his theory explains the facts that: (1) The substitution of talc, pyrophyllite, sillimanite, etc. for the quartz in an electrical porcelain, increases the dielectric strength of the porcelain; (2) That porcelains of given clay content high in felspar and low in quartz are stronger dielectrically than those of low felspar and high quartz; (3) That at the same high potential the disruptive effect of the high frequency current is much greater than that of the low frequency current; (4) That at the same potential the alternating current has a much greater disruptive effect on porcelain than the direct current.

The author further suggests as desirable the development of a substitute for flint which will not interfere with the proper working and burning of the porcelain, and the development of a felspar substitute which while possessing the fluxing and dielectric properties of felspar will be more elastic and less brittle.

SILICA REFRACTORIES FOR GLASSWORKS' USE.—W. J. Rees (*J. Soc. Glass Tech.*, **2**, 253, 1918). Relates to raw materials, silica brick manufacture, texture of silica bricks, behaviour of silica bricks on heating, and silica cement.

THE RELATIONS BETWEEN TRIDYMITE AND CRISTOBALITE.—C. N. Fenner (*J. Soc. Glass Tech.*, **3**, 116, 1919). A discussion based upon statements made by W. J. Rees, Dr. A. Scott, and H. Le Chatelier. The author suggests that sufficient allowance has not been made for differences in temperature on surfaces which may have been exposed for long periods to direct flame heating and at parts which for most of the time have been behind the face and therefore subjected to somewhat lower temperatures. He also points out that few furnaces are operated continuously at the highest temperature, and that the fluctuating conditions make it difficult to draw reliable conclusions upon stability relations. The transformations between quartz, tridymite, and cristobalite, are very sluggish, and this fact along with the tendency to follow Ostwald's law of successive reactions, (by which an unstable form passes through a less unstable condition in its transformation to the most stable form) helps to confuse the true relations, and especially throws doubt on the value of negative evidence. The author

contends that laboratory work based upon almost perfectly controlled temperatures seems inherently more trustworthy and satisfactory. He adds that the most easily determinable distinctive difference between tridymite and cristobalite lies in their indices of refraction, though care should be taken to use suitable liquid. Other distinctive differences are that extinction is strictly parallel to the elongation in lath-like crystals of various angles. The different temperatures of the α-β,—inversions of tridymite and cristobalite also affords a means of discrimination, but special apparatus is required. Experimental evidence is given (most of it now first published) as to the non-stability of tridymite at high temperatures.

Incidentally, it is pointed out that Le Chatelier's fusion point for cristobalite, 1780°C., seems much too high, for cristobalite may be fused completely to a glass in a platinum crucible (set within a porcelain crucible, to avoid direct flame and get more uniform distribution) in a Fletcher gas-furnace. There is no evidence of any effect of the completely melted cristobalite on the platinum, the fusing point of which is 1755°C., so the fusing point of cristobalite must be below 1755°C. The most trustworthy determination of the fusing point of cristobalite is that of Ferguson and Merwin, who put it at 1710 ± 10°C.

REHYDRATION OF CALCINED CLAYS.—J. S. Laird and R. F. Geller (*J. Amer. Cer. Soc.*, **2**, 828, 1919). Report of investigation of the action of very hot water (necessarily under very high pressure) on raw and calcined clays and kaolins. The following conclusions were drawn:

Flint clay cannot be slaked by the action of very hot water in any reasonable length of time, and the plasticity of raw clays is little affected by such action. Clays which have been almost completely dehydrated by calcination at a moderate temperature (600—700°C.) can be rehydrated by heating with water to 200—270°C. for 8—48 hours. The rehydrated material is in general plastic and appears colloidal. After being worked up and dried two or three times it resembles a raw clay—clays which have been calcined at higher temperatures can be rehydrated only much more slowly and incompletely. From the ease with which clays dehydrated at a moderate temperature can be rehydrated and brought back to practically their original condition, it seems probable that on dehydration kaolinite forms an anhydride which is broken down upon heating to higher temperatures, by other reactions such as the formation of sillimanite.

APPARENT VS. TRUE SPECIFIC GRAVITY OF SILICA BRICKS.—L. R. Office (*J. Amer. Cer. Soc.*, **2**, 833, 1919). Samples of bricks were carefully tested for apparent and true specific gravity, the former being determined by taking a 10-gram chip from the brick and boiling it in water for one hour, using a Westphal balance for the weighings.

Of 27 samples tested 22 showed a slightly higher, two the same, and three a lower true specific gravity than apparent specific gravity.

By taking an average of the differences the true specific gravity is found to be 0·011 higher than the apparent specific gravity.

If care is taken to obtain two 10-gram chips as representative as possible of the material in a silica brick, and if their respective specific gravities check within 0·02, the result should be very close to the true specific gravity.

SUPERIOR REFRACTORIES.—R. C. Purdy (*J. Amer. Cer. Soc.*, **2**, 865, 1919). A plea for the institution of thorough researches on refractory problems—possibilities of clay refractories, improvement of silica and magnesite refractories, etc., and also such superior refractories as can be made of zirconia, the spinels, sillimanite, the nitrides, etc. Sillimanite is an excellent refractory of exceptionally low electrical conductivity.

RELATION BETWEEN COMPOSITION AND THERMAL EXPANSIVITY OF PORCELAIN.—F. H. Riddle (*J. Amer. Cer. Soc.*, **2**, 804, 1919). The test specimens used were small rods, pressed in the stiff plastic state in a small hydraulic plunger press (illustrated), which gave rods

remarkably free from lamination. Coefficients of thermal expansion of the fired rods were determined for the ranges 25—200°, 200—400°, and 25—400°C. Time exigencies prevented determinations also at 600°.

Two series of bodies were tested. The first series (13 bodies), contained 70 to 85 per cent. of clay contents, consisting of 50 per cent. raw kaolin, with 20 to 35 per cent. of kaolin calcined at cone 14; the flint ranged from 18·5 per cent. down to none, the felspar from 10 to 28·5 per cent., and in each mixture was included 1·5 per cent. of whiting. The silica content varied gradually from 64·59 to 55·93 per cent., and there were no marked variations in the coefficients of expansion Two porcelain bodies of normal clay content (50 per cent.) were also tested, containing also 16 of felspar, with 34 of flint in one, and 32·5 of flint and 1·5 of whiting in the other. The second series (10 bodies), contained 50 per cent. raw kaolin, and 5 of them were the same as 5 of the previous bodies; the other 5 contained 30 per cent. synthetic, sillimanite replacing flint (and calcined clay to make up with flint the 30 per cent.), the felspar and whiting being as in the first 5 bodies. In only one case was a small excess of flint left. The sillimanite is, of course, much more constant in volume with reference to thermal expansion.

Bodies high in clay substance show low thermal expansions, fairly independent of the small variations in flint content which are possible. As the clay content of porcelain is lowered and the amount of quartz (or flint) becomes larger, its effect as regards thermal expansion becomes more marked. As sillimanite replaces flint in the bodies lower in clay content the reduction in thermal expansion is much more marked than in those bodies in which the clay content is high. As the content of clay increases the difference becomes smaller; the final body, with 85 per cent. of clay, is not improved by the sillimanite substitution. The flint is undoubtedly the greatest factor in causing increased thermal expansion, not only by virtue of the properties of the crystalline quartz, but also through the increase of the silica content of the body. Upon replacing the flint by any substance more inert as regards thermal expansion, the general effect is a decrease in the thermal expansion, and calcined kaolin may be as effective in this respect as sillimanite or other synthetic silicates.

Bars made of the synthetic sillimanite and fired to cone 26 showed linear thermal coefficients of expansion of $10^{-6} \times 2{\cdot}7$ at 25—200°C., $\times 3{\cdot}9$ at 200—400°C., and $\times 3{\cdot}3$ at 25—400°C.

FURTHER STUDIES ON PORCELAIN.—F. H. Riddle (*J. Amer. Cer. Soc.*, **2**, 812, 1919). Relates to the effects of further variations in composition and also of different methods of preparation. Photomicrographs, tables, and curves are given by way of illustration, etc.

The effect of small additions (0·2 and 1·0 per cent.) of magnesia and of lime was investigated, the base composition being 39 kaolin, 6 ball clay, 37 flint, and 18 potash felspar, and the substitution being made at the expense of the felspar. Without these additional fluxes the body requires a higher temperature to reach maturity, and the maturing temperature is lower with magnesia than with the same amount of lime. There were notable differences in the appearance of thin sections under the microscope, as regards solution of quartz, formation of sillimanite, etc. The translucency of the bodies containing magnesia or lime was as great at cone 11 as that of the body with only felspar at cone 14, indicating more glass formed. The use of lime, like magnesia, increases the formation of sillimanite as well as the solution of the quartz, probably owing to decreased viscosity of the body.

In trials with other bodies containing 3 per cent. of whiting, or dolomite, or mixtures of them in various proportions, good results were obtained, and the use of dolomite produced bodies of superior toughness or resistance to chipping.

The water of plasticity and the drying shrinkage are increased by longer grinding, notably after 24 hours. Probably grinding too long tends to give a body which works unsatisfactorily, especially in large cylinders, where

even one extra hour of the very much more intense grinding may bring about a considerable change. Finer grinding causes earlier maturity and earlier overfiring. The body when ground 3 hours matured at 1340°C., and when ground 48 hours reached zero absorption at 1290°C. The effect of longer grinding seems to be equivalent to an increase in felspar or other fluxes or in ball clay. Longer grinding may apparently be practiced with bodies low in ball clay to reach maturity without increasing the ball clay (as might otherwise be necessary). No essential differences were noticed in the microstructures of bodies ground for different lengths of time.

SILICA REFRACTORIES. FACTORS AFFECTING THEIR QUALITY AND METHODS OF TESTING THE RAW MATERIALS AND FINISHED WARE.—D. W. Ross (*Bureau of Standards, Tech. Paper* 116, 1919). Silica bricks are used in regenerative and coking chambers of bye products coke plants; tops, ends and sometimes walls of open-hearth furnaces, etc. Numerous data are given concerning American products. See abstract in *J. Amer. Cer. Soc.*, **2**, 671, 1919. Owing to small percentage of flux, quartzite is transformed into cristobalite in firing, but after 70 per cent. has been inverted, tridymite appears and develops slowly with continued heat treatment. Excepting special cases, the specific gravity of silica bricks is between 2·65 and 2·27 and specific gravity determinations show the degree of firing the brick has had. In firing, the volume of solid material increases 10-15 per cent. The average brick contains about 27 per cent. pore space, and the porosity of fired bricks is greater than that of the raw mixture. Minimum porosity can be obtained by raising the temperature at the usual rate to 1250—1350° and holding for several days. Transformation of quartz will then proceed at moderate rate and the soaking will permit the fluxes to exert maximum effect in drawing the materials together, thus keeping increase in pore space down to a minimum. The temperature should finally be raised to cone 18—20. The chief thermal volume changes in silica bricks are due to tridymite inversions below 200° and the alpha-beta cristobalite inversion at 220°—300°. Practically all spalling occurs between atmospheric temperature and 300°.

A mixture which yields satisfactory results shows the following screen analysis: residue on 8-mesh 15·3 per cent., 16-mesh 13·4, 20-mesh 4·6, 30-mesh 5·4, 40-mesh 4·8, through 40-mesh 56·5 per cent.

6·8 per cent. lime increases the speed of the quartz inversion, and does not appreciably lower the fusion point.

General characteristics of best grade silica refractories: Shall contain not less than 95 per cent. silica, shall not fuse below cone 31, specific gravity not above 2·384, permanent exterior volume expansion at 1500°C. for 1½ hour not above 6 per cent., strength of tests should show average modulus of 540 and effective modulus of rupture of about 284, under 25 lb. load at 1500°C. for 1½ hour shall not increase more than 2 per cent. or decrease more than 1 per cent. in length.

EFFECT OF EXTRACTION UPON THE PLASTICITY OF CLAY.—W. A. Hamor and H. E. Gill (*J. Amer. Cer. Soc.*, **2**, 594, 1919). Relates to the result of using organic solvents—alcohol, benzol, acetone, etc. It was found that certain clays after being treated with organic solvents are less plastic than the original materials, but not to the same extent for different solvents.

MACHINE FOR TESTING THE HOT-CRUSHING STRENGTH OF FIREBRICKS.—H. G. Schurecht (*J. Amer. Cer. Soc.*, **2**, 602, 1919). An illustrated description of the machine and the method of using it, with results of tests, the bricks being subjected to a load of 25 lb. per square inch while the temperature was being raised to 1300°C. for fireclay bricks, 1350°C. for magnesite and chrome bricks, and 1500°C. for silica bricks.

THE POLARIZING MICROSCOPE IN CERAMICS.—A. B. Peck (*J. Amer. Cer. Soc.*, **2**, 695, 1919). A discussion of its applications. Reference is made to the use of thin sections, originally devised by Sorby, and to

the method of "immersed grains," recently developed in the Geophysical Laboratory at Washington. In the latter method the substance is crushed to a fine powder, immersed in a liquid of known refractive index, and the optical properties studied; it permits optical constants to be determined in different directions on the same fragment, and avoids difficulties arising from overlapping grains; the main disadvantage is the loss of structure and texture which sometimes results.

Properties which may be studied qualitatively are such as form, colour, cleavage, fracture, optical vibration and directions, and pleochroism.

The four most important quantitative measurements are the index of refraction, double refraction, size of the optical angle, and extinction directions and angles. The first named of these is much the most important, and methods of determining it are described.

The examination of ground felspar (and other powders) is alluded to as a rapid means of gaining useful information regarding impurities, etc. Reference is also made to the use of the microscope in connection with cement clinker, porcelain, glass pots, refractory bricks of different kinds, etc.

VOLATILIZATION OF LEAD OXIDE FROM LEAD SILICATE MELTS.—O. Andersen (*J. Amer. Cer. Soc.*, **2**, 784, 1919). It was found that the volatilization from an unstirred lead silicate glass in 15 minutes took place at practically the same rate as from a stirred glass heated longer (1 hour). The rate falls off greatly during a long heating without stirring. The rate of volatilization of PbO at temperatures usually used in optical glass manufacture would seem to be small enough to avoid material variations in refractive index due to volatilization if the procedure is reasonably constant from melt to melt, but large enough to cause considerable variations in index if the melting schedule is changed.

HIGH-FIRE PORCELAINS.—C. C. Lin (*J. Amer. Cer. Soc.*, **2**, 622, 1919). In the manufacture of most American china, vitrification is brought about in the biscuit firing, the ware being embedded in sand, ground kaolin, or flint, and there is not excessive warping. The glaze is matured at a temperature (generally not above cone 5) low enough to avoid danger of warping. But these softer-fired American wares are not as translucent as the true porcelains of Europe and Asia; their glazes are inferior in hardness, and their smooth glossy surfaces are not so attractive as the egg-shell surfaces of the true porcelain glazes.

Cone 13 is the minimum temperature at which crystalline sillimanite forms in quantity in porcelain, and is said to produce the fine blue-white translucency of the true porcelain. To bring out its beauty, the glaze must be of the true unfritted porcelain type, free from lead oxide, and with a maturing temperature safely below that at which distortion would begin; its composition must also be suitable for the body.

The present investigation covers 29 porcelain bodies the composition of which lies within the limits of 10—20 per cent. felspar, 30—45 flint, 30—45 clay, 10 per cent. ball clay. The range includes ordinary whiteware and chemical porcelain bodies. Trial bodies were fired to cone 10 and to cone 13—14. Results are shown in tables and diagrams.

Discussion of the glaze is postponed. The following conclusions are drawn as regards the bodies. Very broadly speaking, the drying shrinkage and total shrinkage increase with increase in clay content, but show great irregularity. With bodies containing 20 per cent. felspar (along with clay ranging from 40 to 50, and flint ranging from 40 to 30 in stages of 2·5 per cent.) the total shrinkage was smaller at cone 13—14 than at cone 10, owing to vesicular structure following overburning. The same was the case with 3 bodies containing 15 per cent. felspar (along with 50 to 55 clay, and 35 to 30 flint), and a body consisting of 17.5 felspar, 47.5 clay, and 35 flint. None of the bodies was thoroughly vitrified at cone 10, but all containing 15 to 20 per cent. felspar became non-absorbent at cone 13—14. The bodies containing 12·5 per cent. felspar absorbed a little water, and these with 15 per cent. absorbed more. The bodies showed a considerable increase in

cross-breaking strength when fired at cone 13—14, except those with 20 per cent. felspar, which showed only a small increase; the increase in strength was generally greater in bodies low in felspar and high in clay, the felspar being more active. The warpage of the bodies at cone 13—14 varied very irregularly; as a whole it was not excessive. The bodies fired at cone 10 were semi-translucent, while those fired at cone 13—14 showed distinct translucency. The colour of the bodies was distinctly improved by firing at a higher temperature, changing from a creamy tint to a beautiful bluish-white. In the bodies fired at cone 13—14, the colour tended to become pinkish with decreasing felspar. Toughness appears to depend more on the amount of flint present than on either felspar or clay. Taking all into account, the best bodies fired at cone 13—14 contained 15 felspar with 52·5 clay and 32·5 flint, and 12·5 felspar with 47·5 clay and 40 flint, respectively.

SOME PROPERTIES OF BOND CLAYS FOR GRAPHITE CRUCIBLES.—M. C. Booze (*J. Amer. Cer. Soc.*, **2**, 461, 1919). Report of investigation with nineteen American clays, English ball clay, and Klingenberg crucible clay (German). The tests made covered water of plasticity, resistance to slaking, ratio of pore to shrinkage water, ratio of pore water to true volume of the body constituents, a classification of the clays as to working qualities when used with graphite, dry and burned transverse strength, the degree in which the clay aids in resistance to oxidation of the graphite, loss in strength from sudden cooling, and the softening points of the clays alone. Results are shown in tables and by means or curves.

No single clay satisfies (or can satisfy) to a high degree all requirements for graphite crucible use. The average strength of bodies in which graphite is used is considerably higher than that of those in which sand is used, probably owing to difference in shape of grains, and similar differences were found in using different graphites.

In discussion it was stated that Dorset ball clay had given good results as a substitute for Klingenberg clay.

DIRECT VOLUME DETERMINATION.—J. B. Shaw (*J. Amer. Cer. Soc.*, **2**, 481, 1919). Relates to the use of a volumeter of the pycnometer type, which is figured. Besides the volumeter, there was required for making volume determinations only a burette reading accurately to 0·1cc., so that volumes can be estimated to 0·05cc. The chief claims are speed, simplicity, cheapness, and sufficient accuracy.

In discussion, H. G. Schurecht explains how to save time by making the balance read automatically for fractional gram intervals, and by using tables for volume calculations.

APPARATUS FOR DETERMINATION OF AIR IN CLAY.—H. Spurrier (*J. Amer. Cer. Soc.*, **2**, 490, 1919). Relates to a simplified apparatus for determining the air in pugged clay. The apparatus is figured.

STRUCTURE OF GRAPHITE IN RELATIONSHIP TO CRUCIBLE MAKING.—R. Thiessen (*J. Amer. Cer. Soc.*, **2**, 508, 1919). An illustrated account of an investigation of graphite crucibles, including microscopic examinations. The results are discussed with special reference to important factors. Peptization of clays is also briefly alluded to.

EFFECT OF ELECTROLYTES ON THE PROPERTIES OF GRAPHITE CRUCIBLE BODIES.—H. G. Schurecht (*J. Amer. Cer. Soc.*, **2**, 443, 1919). The addition of NaOH to graphite crucible bodies containing Dorset bond clay spoiled the working properties of the bodies, but improved the moulding quality of bodies containing Mississippi bond clay; HCl had an opposite effect, improving the working properties of the body containing Dorset clay. Small additions of NaOH to bodies containing Dorset clay decreased the dry transverse strength, but larger additions increased it. Addition of NaOH to a body containing Mississippi clay increased the strength. The dry strength was increased by grinding the flake graphite with the NaOH and water before mixing with the clay.

Small additions of NaOH decreased the density of bodies containing Dorset clay and increased the density of bodies containing Mississippi clay. Larger additions produced the opposite effect, as HCl did. Small amounts of HCl made the body containing Dorset clay more open, but a larger percentage made the body less porous, as did also NaOH. The porosity of bodies containing Mississippi clay was decreased by small percentages of NaOH, but increased by larger amounts. NaOH seemed to increase the shrinkage of bodies containing Mississippi clay, and to first decrease and then increase the shrinkage when Dorset clay was used. The action of the acid was again opposite to that of the alkali. When NaOH was added to slips containing Alabama flake graphite and Dorset clay, the viscosity was increased, but upon adding more alkali it was decreased again. This increase in viscosity was much less pronounced when Ceylon graphite or Alabama coked graphite was used instead of the flake graphite. With Mississippi clay used instead of Dorset clay, small additions of NaOH decreased the viscosity.

RADIOACTIVE BRICKS.—H. J. Knollman (*J. Amer. Cer. Soc.*, **2**, 451, 1919). Has relation to briquettes or rods—generally called bricks or plates—made from mixtures of clay with insoluble radium sulphate in a state of fine subdivision. When placed in water in tightly closed bottles, these bricks or plates give off radium emanation which dissolves in the water, the solution being taken as a sort of tonic. The strength of radioactive water is usually given in Mache units per litre, a Mache unit being 0·001 electrostatic unit (one of which $= 3{\cdot}33 \times 10^{-10}$ ampere).

Particulars are given as to the preparation of the plates. Any good clean clay low in soluble salts, and maturing with the addition of less plastic clays and non-plastic material to a hard body at about cone 08, can be used.

TESTING HARDNESS OF MATERIALS.—A. French firm (*Pat. J.*, No. 1566, 1919). Pat. No. 120,884, Oct. 23, 1918. The hardness of a body is tested by pressing a diamond against its surface with a gentle pressure and measuring the force required to move the diamond along in opposition to the resistance of the body.

MEASURING PRESSURE BETWEEN BODIES.—A Swedish Firm (*Pat. J.*, No. 1572, 1919). Pat. No. 121,946, Dec. 19, 1918. The pressure between bodies in contact, which bears a definite relation to the deformation produced, is determined by etching the portions around the surface of contact while under pressure and deducing the pressure from measurements of the unaffected parts. The composition of an etching liquid for iron and steel bodies is given in the specification; in the abridgment the components are mentioned but not their proportions.

TESTING MACHINES.—G. H. Denison and S. C. Brown (*Pat. J.*, No. 1574, 1919). Pat. No. 122, 307, Feb. 28, 1918. Relates to automatic stress-strain-recording apparatus used on testing machines.

THE TERNARY SYSTEM CaO-MgO-SiO_2.—J. B. Ferguson and H. E. Merwin (*Amer. J. Sci.*, **48**, 6, 1919). The general behaviour on heating to high temperatures and the properties of the compounds and solutions formed have now been determined for the four possible ternary systems from the oxides CaO, MgO, Al_2O_3, SiO_2, namely, CaO-Al_2O_3-SiO_2, CaO-MgO-Al_2O_3, MgO-Al_2O_3-SiO_2, CaO-MgO-SiO_2. The results should not be applied to ceramic problems without the aid of data on the practical properties of the ceramic products. For example, the results indicate that in a certain type of porcelain CaO would give a greater degree of fusion than MgO would with like heat treatment, from which it might be supposed that CaO would give greater translucency than MgO, whereas the reverse is true in this particular porcelain, which is of the average American type; other factors, perhaps small amounts of other oxides, seem to govern translucency more than the supposed greater fluxing action of the CaO does.

The relations found in the system CaO-MgO-SiO_2 are shown in a trian-

gular concentration diagram (on a weight per cent. basis) with isotherms showing the temperatures of complete melting of the various compositions. See abstract in *J. Amer. Cer. Soc.*, **2**, 844, 1919, in which the diagram is reproduced. The system CaO-MgO-SiO_2 is the most complicated of the four mentioned above, on account of the great number of solid solutions which may form; there are 14 crystalline phases (oxides, compounds, and solid solutions) found in this ternary system. There are also 14 quintuple or invariant points at which three crystalline phases and a liquid can co-exist, and six of these are true eutectics. The lowest melting eutectic mixture in the system consists of 32 per cent. CaO, 7 MgO, and 61 per cent. SiO_2, which melts at 1320°C., whilst without the MgO the melting point would be about 1500°C. It is such low melting mixtures that become effective as fluxes in pottery bodies and glazes.

TESTING HARDNESS OF MATERIALS.—L. J. Richardson, and W. and T. Avery (*Pat. J.*, No. 1591, 1919). Pat. No. 126,463, May 10, 1918. The hardness of materials is determined by the force required to overcome the static friction exerted by a weighted abrasive surface applied to the material. The force—applied by an electro-magnet, by springs or weights, or hydraulically—is gradually increased until the friction between the surface and the test piece is overcome.

TESTING HARDNESS OF METALS.—B. W. Winder, and W. Burgan (*Pat. J.*, No. 1593, 1919). Pat. No. 127,412, June 1, 1918. In apparatus wherein a hard steel ball is forced by a known pressure into contact with a test-piece, the ball is carried by a system of levers and a quick release is provided to allow the test to be rapidly applied.

TESTING HARDNESS OF MATERIALS.—R. A. Craig, H. Moore, and R. Mather (*Pat. J.*, No. 1597, 1919). Pat. No. 128,894, Jan. 31, 1916. Consists of apparatus adapted to press a hard-steel ball into the surface of the test specimen by means of a known weight suspended freely on the ball.

TESTING MACHINES.—F. Figari (*Pat. J.*, No. 1600, 1919). Pat. No. 129,603, March 19, 1919. In a portable testing machine for tension, compression, and Brinell tests, the stresses are applied by means of a differential screw, and are measured by the deflection of a plate connected through lever, etc. mechanism to a pointer.

TESTING PHYSICAL QUALITIES OF MATERIALS.—E. A. Allcut (*Pat. J.*, No. 1601, 1919). Pat. No. 130,165, July 29, 1918. The mechanical drive for the poise weight of a testing machine is transmitted to the poise weight through a clutch or clutches controlled by a manually operated member. Two forms are illustrated.

TESTING MACHINES.—J. C. W. Humfrey (*Pat. J.*, No. 1614, 1919). Pat. No. 134,082, Nov. 25, 1918. A notched-bar testing-machine is so constructed and arranged that it gives, during a test, a diagram of applied bending-moment and deflection produced in the specimen, and indicates also the work expended in bending or breaking the specimen.

LATENT HEAT OF FUSION OF CRISTOBALITE.—E. W. Washburn (*J. Amer. Cer. Soc.*, **2**, 1007, 1919). The only means for estimating the heat of fusion of quartz is by applying the law of freezing point lowering, and the application must be to "dilute solutions." According to Rankin and Wright the composition of the eutectic (melting at 1610°C.) between cristobalite and sillimanite is 87 per cent. silica and 13 per cent. alumina. From these data and the usual formula the author calculates the probable value of the latent heat of fusion.

RESISTANCE OF INSULATORS AT HIGH TEMPERATURES.—F. B. Silsbee and R. K. Honaman (Report No. 53 of the National Advisory Committee for Aeronautics, p. 1, 1919). The method of measuring resistance at high temperatures is described, the range studied being 200°—900°C. Some results are given.

STUDIES ON CLAYS, I.—Sven Odén (*Bulletin of Geol. Inst. Upsala Univ.*, **15**, 175, 1916). A general introduction to the chemistry and physical chemistry of clays.

The first experiments on coagulation and effect of salt on clay suspensions were made in 1912 in connection with the author's work on the fractional coagulation of colloids. It was when he extended the experiments to a coarser material that he became aware how heterogeneous even the most highly disperse and strongly plastic clays are. This gave impulse for working out a new method of mechanical analysis of soil, as well as studies on adsorption, and chemical composition, etc., of some clays. These will be reported in the next volume.

Kaolinite—hydrated aluminium silicate—was formerly generally considered to be an essential constituent of clay. Later soil-zeolites took the place of kaolinite ((Th. Way, J.M. Van Bemmelen, R. Gans), and in the most recent period soil-colloids of different species: colloidal silica, alumina (hydrated), iron oxide, allophane clays, etc. (F. Cornu, P. Rohland, H. Stremme, and others). A. D. Hall represents a view different in principle. According to him it is not the chemical nature of the substance which characterizes clays, but merely the degree of fineness of the ultimate material particles. A. Atterberg has also adopted substantially this view, although he admitted that for Swedish recent clays muscovite and biotite may be the characteristic minerals. The author suggests that the following definition of clays correspond to all experimental facts: Clays are disperse formations of mineral fragments in which particles smaller than 2μ predominate. ($2\mu = 0.002$mm). Among these mineral fragments may occur quartz, felspar, mica, and others, as well as their various decomposition products: kaolin, bauxite, hydrargillite, zeolites, allophane clays (Stremme), gelatinous silicic acid, iron oxide, etc., but none of these ingredients is necessary to characterise a surface deposit as clay. It is only necessary that very small particles shall predominate. As limit (according to Atterberg) 2μ is fixed provisionally, and as the major portion perhaps half is in question, but of course, these limits possess no strict validity, and such deposits, in which particles of 2—5μ diameter preponderate, bring about the transition to poor clay formations. It is also very probable that these limits, within which the characteristic clay properties appear are dependent on the chemical material, and a clay with preponderating kaolin and quartz must probably be much finer grained than a clay, for example, from biotite and hydrated silicic acid, in order to produce plasticity and strength in typical development.

As disperse structures, are designated in physical chemistry two-phase systems, in which one component—for example, the solid phase (here the mineral grains)—occurs in finely divided (disperse) form, and is distributed in the other component, the dispersion medium (for example, water).

But whilst in colloidal solutions and in most cases also in gels the disperse phase constitutes the smallest part of the system (often a few per cent. at most), in clays the disperse phase preponderates, and the dispersion medium (water, water-vapour, and air) is only to be regarded as a filling in the interstices between the mineral particles.

Clays are also, in contrast to most other colloidal systems, in a high degree uneven-grained, that is, they consist of particles of all possible sizes, from millimeter sandgrains to particles of one hundred thousandth of a millimeter ($0.01\mu = 10\mu\mu = 0.00001$mm.). The importance of the percentage distribution of the mineral grains on the different sizes of groups for classification and valuing of clays will be discussed fully.

An extraordinarily large development of surface goes hand in hand with this great subdivision. Attempts have been made to determine this total surface from the water-holding of the clay (the hygroscopicity of Mitscherlich), and numbers like 200—900 sq. metres for one gram of clay substance were given, but these numbers are probably estimated a little too high. This large surface also renders it possible that the most varied salts as well

as gases are adsorbed by the particles and remain adhering and are protected from being washed out.

Although according to the foregoing conception it is not the chemical or mineralogical nature of the material, but only the heterogeneous subdivision of this material that is of outstanding importance for the external properties of clays, of course the nature of this material plays a great part for the agricultural chemical and technical value, and for the precise characterisation of individual clays. Here methods of chemical analysis must be made use of. Complete analysis, which gives the total composition of the clay, is free from objection. But to designate as zeolitic decomposition silicates what is soluble in hydrochloric acid, and as kaolinic components what is soluble in concentrated sulphuric acid, as was formerly customary, is misleading. For in complete methods of extraction regard must be had to the degree of fineness of the material. The finer the mineral grains, the more easily they are attacked by acids, and perhaps with the exception of quartz small particles of minerals of every kind are decomposable by hydrochloric acid (Zemgatschensky, A. Vesterberg).

Other theories concerning clays are reviewed. The oldest, originated by Davy and Forchammer, and upheld by many others, conceived clays as being more or less impure kaolins. Certainly in many cases felspars by weathering are transformed into kaolin, and many clay deposits show a composition approximating to that of kaolin; in other cases, externally similar, it is reasonable to assume that kaolin is the essential constituent, which is only more or less contaminated by other silicates and especially by ferric silicate. But many analyses gave such large amounts of aluminium hydroxide and alkali that only a small part of kaolin could be present, and direct kaolin analyses by the sulphuric acid method often showed only a few per cent. of kaolin. Finally it was shown (by Hilgard 1893, Atterberg 1907) that pure kaolin exhibited neither the great plasticity nor the great adsorptive power of clays, which brought Atterberg to the conclusion that it is not the kaolin, but other substances, which confer on clays their characteristic properties. They are zeolites which are now pressed into the foreground of interest, and are considered as carriers of the clay properties.

The conclusions of Hilgard and Atterberg were correct, if the kaolins investigated by them had shown the same degree of subdivision as that of the clays compared with them. But this has probably not been the case; it is the mixture of coarse and quite fine particles which counts essentially in the phenomena of plasticity. Atterberg later (1915) recognised that fine kaolin is actually plastic. The old view that finely subdivided kaolin constitutes a main ingredient of decomposition clays may be correct then in many cases. But it is not their property of being kaolin that confers on clays their clay properties, but their property of occurring in a highly disperse form (finely subdivided).

Towards the end of the nineties the peculiarities of the zeolite minerals excited a lively interest. It was shown that their water of crystallization does not escape at a constant vapour tension, that they are able to take up carbon bisulphide, benzol or alcohol, instead of water without changing the external form of the crystal, that they stored up large quantities of salts from salt solutions, and that for example a soda zeolite simply by repeated treatment with a solution of a potassium salt can be transformed into a potash zeolite. These peculiarities, which to-day can be explained by assumption of a large interior surface of ultra-miscropic structure (of similar nature to a piece of sponge or cocoa-nut charcoal, only of incomparably much smaller and probably more regularly developed structure), roused the interest of the soil chemist, and at that time the common properties were taken as proof of the presence of zeolites in clays (Way, Van Bemmelen) The arguments of Van Bemmelen are particularly clear and synoptical. Clays are especially distinguished by their high adsorptive power towards salts, which for the arrest of plant nourishment is of particularly great importance for the fertility of the soil. If a soil is absorptively saturated

with calcium and magnesium salts, and a solution of potassium or ammonium salt is added, exchange, nearly according to equivalent proportions, takes place, so that as many equivalents of calcium salts are set free as correspond to the combined potassium salt. Inasmuch as artificial (permutite) as well as natural zeolites exhibit these changes, but not kaolin, these adsorption phenomena must be attributed to the zeolites of the soil. Van Bemmelen now identifies the decomposition silicate soluble in hydrochloric acid with these zeolites of the soil, and in fact was able to prove that clays rich in material soluble in hydrochloric acid showed a strong absorption action, whilst clays poor in material soluble in hydrochloric acid adsorbed only insignificant quantities. From the point of view of the investigator at that time the above conclusions are quite justified, and in consequence of the changes taking place nearly according to chemical proportions, were really convincing.

But later physico-chemical investigation has shown that it is just the strongly developed surfaces (large specific surfaces, that is, a large development of surface per unit weight of the substance), which determines the proper place of the adsorption action, and further that equal surfaces bind nearly equivalent quantities of the different adsorbed substances. This applies also where (for example in coagula of colloidal arsenic trisulphide or colloidal sulphur) a chemical combination, according to older views, is not conceivable. The quantity adsorbed is of course greatly dependent on the grain size and the surface varying with that, and not proportional to the actual weight of the substance, when these exhibit different dispersity.

Clays as well as zeolites have a large surface development, clays the large outer surface of the very fine particles, zeolites a large inner surface developed in the interior of the crystal. Both substances show similar adsorption actions. It is therefore quite correct that it is the very fine components of clays which cause the adsorption phenomena, and it is also these which are specially attacked by the hydrochloric acid. Nevertheless no cogent reasons exist for assuming the presence of particular zeolite minerals in clays, although a subordinate occurrence of such is of course not excluded. Van Bemmelen himself appears not to have assumed the occurrence of specially developed minerals: he speaks rather of a colloidal complex of various colloidal compounds of alumina and ferric oxide with silica, the alkaline and alkaline earthy bases absorbed.

We are here tolerably near the most modern conception, which ascribes to the colloids of the soil that part as carrier of the clay properties. (Cornu, Rohland, Stremme and others).

Modern colloid chemistry is essentially a science of the last decade. The application of colloid chemistry to the science of soils is owing in the first place to F. Cornu. It was gradually established that crystals, amorphous bodies and fluids appear as colloidal structures, and that the colloidal character is not connected with certain substances, but is to be conceived as a general state of matter arising under certain conditions. The soil colloids are represented as gelatinous formations consisting of colloidal silicic acid, colloidal aluminium hydroxide, colloidal ferric oxide. Though there is certainly some truth in all the efforts which have been made to elucidate the question, these certainly often present colloidal gels can characterise clays just as little as kaolin or the zeolites. The true soil colloids are those multifarious fragments of both decomposed and undecomposed minerals, crystal splinters and amorphous substances, which in finely subdivided form build up clays. As the particles—whatever their chemical nature—become coarser and coarser the material gradually passes more and more into poor clays, loams, sands.

Following the historical summary, the author proceeds to discuss the characterisation of clays by means of distribution curves. Two soils can show almost the same numbers for mechanical analysis, and yet be very different with regard to the constitution of their grains. Accordingly all their physical properties must be different. This is the most substantial

reason why classification according to the results of mechanical analysis of soils remains unsuitable, and must be gradually abandoned. The mechanical soil analysis designates all particles smaller than 2μ ($=0.002$ mm.) as clay. Since these very small particles are just the characteristic components of clays, but can be of varying degrees of smallness in different clays, the greatest importance much be attached to the characterisation of these smallest particles. Here can be applied the colloidal chemistry technique worked out by R. Zsigmondy by counting the number of particles in a limited volume of a suspension of known concentration, but even such a process is imperfect, for it gives only information concerning the average value of the size of particles, and this value can often deviate considerably (several hundred per cent.) from the actual size of particle of the most numerously represented particles. Research into the distribution, that is, the weight or the number of particles corresponding to each size of particle, seems accordingly very desirable. The author proposed the expression "equivalent radius" of a particle to indicate the radius of a sphere of the same material which in a fluid sinks with the same velocity as the particle. The precise mode of movement and the laws of such movements of small particles in fluids were likewise evolved. Distribution curves were first used by Clerk Maxwell, in connection with the different velocities of the molecules of a gas. The application to earthy deposits presumes the possibility of graphically expressing the quantity of particles as a continuous function of the equivalent radius. In the curves used for illustration the different values of the equivalent radius are represented by abscissae (marked along a horizontal line) within a range up to 100μ ($=0.1$ mm) and as ordinates (marked along a vertical line from below upwards) were marked off in each case a number specifying how much per cent. of the sample consists of particles larger than this equivalent radius. For equivalent radius $0, 10\mu$, 30μ, the corresponding number (per cent.) would be 100, 75, or 50 respectively—meaning that 75 per cent. of the sample consists of particles larger than 10μ, 50 per cent. of particles larger than 30μ, etc. Therefore between 0 and 10μ there is $100—75=25$ per cent., between 10μ and 30μ there is $75—50=25$ per cent., etc. Thus to obtain the percentage quantity between two given abscissae, the ordinates which correspond to the largest equivalent radius are to be substracted from the ordinates of the smallest, to which the difference of the quantity of particles corresponds. This graphic function accordingly falls from 100 for the smallest particles to zero for the largest particles of the sample. If the curve takes a horizontal course, it signifies that in that interval no particles are present.

For the treatment of certain problems the quoted representation of the composition of an earthy deposit is particularly suitable. But it is better and clearer in most cases, if we wish to obtain a perception of the quantity-proportions of the different fractions, to represent the quantity of particles not as a straight line, but as a plane surface. This is done by taking abscissae as before to represent equivalent radius, and choosing as ordinates magnitudes such that, multiplied into a fraction of the abscissa-axis, it gives a plane surface, which then determines the quantity of particles in the abscissa interval in question. The quantity of particles is here represented by an integral, and the quantity of particles between two given values of radius is obtained simply as the surface which is bounded by the abscissa-axis, the corresponding ordinates, and the curve. Practically the calculation is carried out so that the total surface constitutes a hundred units on millimeter paper, and for the different intervals only the squares have to be reckoned in order to get the percentage.

In cases where particles of very different size are present, the use of the radius as abscissa would make the curve inconveniently long, so instead of the radius the natural logarithm of the equivalent radius is taken, and by a suitable change in the ordinates, using $r.\,F(r)$ instead of $F(r)$, the surface content would remain unchanged while the curve would run somewhat differently and be more convenient. According to Atterberg's investiga-

tions, the radius equivalents 1μ, 10μ, and 100μ are the most suitable for characterizing the groups clay, poor clay, fine sand, and coarse sand—clay having particles less than 1μ, poor clay between 1μ and 10μ, fine sand between 10μ and 100μ, and coarse sand above 100μ.

An earthy deposit is accordingly a clay material, a poor clay material, or a sand, according as the main quantity falls in the clay, poor clay, or sand region.

The properties of strength, plasticity, permeability to water, etc., are not only conditioned by the main quantities and their fineness, but also by the components occurring in subordinate amount, therefore to a high degree depending on the kind and character of the distribution curves.

The distribution curves therefore characterise loose earthy deposits in far more complete manner than the numbers of the mechanical analysis. Investigation of these distribution curves can be made by carefully washing up the clays in water, and then studying the speed with which sedimentation results. This is done by keeping a thin plate (placed closely over the bottom of the sedimentation vessel), suspending on a scale-beam, and from time to time finding the weight of the precipitated particles. The speed of this accumulation of particles is of course at every moment dependent on the number as well as the size of the particles—therefore on the distribution—and can be calculated from these. How this is to be carried out experimentally, and proceeded with by calculation the author promises to communicate in the next volume, and also to give the distribution curves of some typical Swedish loose deposits.

From the distribution curves can be calculated approximately the total surface, and thus not only the quantity of particles, but also the number of particles can be represented as a function of the equivalent radius.

With reference to the origin and metamorphosis of clays, the author makes a general allusion to the processes of kaolinisation, lateritisation, saussuritisation, serpentinisation, sericitisation, zeolitisation, etc., Very little is known concerning these processes; it can only be stated quite generally that with increasing moisture and temperature, decomposition gives rise to more simple compounds, and that ferric hydroxide, bauxite, silicic acid, belong rather to tropic than temperate zones. In these reactions, collectively termed chemical decomposition, crystallised (kaolinite, sericite, etc.) as well as amorphous minerals (amorphous kaolin, ferric oxide, allophane clays, etc.) arise, but in the author's opinion it is going too far to regard the decomposition minerals primarily as colloidal substances. However, since these substances collectively have a much lower degree of hardness than the original minerals, they will much more easily fall to separating agents and easily give rise to highly-dispersed systems. A clay which arises from such minerals previously strongly changed chemically, possesses therefore a different character than a clay which has arisen from fresh primitive rock materials. In the latter small crystal fragments will predominate, whilst the former consists rather of amorphous substances, as can be well observed in ultramicroscopical investigation. For both kinds of clay formation, however, are to be added secondary processes. A crystalline clay will be influenced by chemical decomposition processes just as much as primitive rock material, the originally fresh mineral grains will be attacked first on the surface, then in the interior, and finally essentially new mineral formations are met with. In an amorphous clay by protracted stratification and pressure in the beginning amorphous substances can be changed into crystalline (as in the changing of opal into chalcedony, of gelatinuous hydroxides of aluminium and iron into crystallized compounds, etc.). The amorphous condition is not a stable state, and there is now a growing tendency to consider such substances as cryptocrystalline. In nature the above processes overlap one another, and it may often be difficult to decide whether amorphous or crystalline formations occur. But both can appear highly or coarsely disperse and accordingly as more or less colloidal bodies.

The colour methods used for determination of the soil colloids appear to indicate that it is chiefly the amorphous minerals which adsorb the colour substances. On the other hand, kaolinite and certain crystallised silicates of alkaline earths strongly adsorb colouring substances. To the author the colouring substances seem little suited for the purpose, partly because the quantity adsorbed varies greatly with the salts present and depends on the hydrogen and hydroxylions present possibly in the soils, partly because these substances stand on the boundary between highly disperse colloids and genuine (molecular disperse) solutions and therefore give rise to complicated phenomena.

The author considers the work of R. Marc of greater importance for the present question. This investigator proved that crystallised substances adsorb comparatively little from solutions of well-crystallising bodies, like kinds of sugar or alkali salts, but on the other hand copious quantities of dextrin, gum arabic, casein, and similar substances. Amorphous substances, like charcoal, Jena glass utensils, etc., show just the reverse, adsorbing strongly typical crystallising substances, but little from solutions of amorphous substances. The results of some experiments carried out by the author indicate that by the so-called decomposition clays usually crystalline substances are absorbed, while by the recent clays amorphous substances are generally absorbed. This method of characterisation must, however, be extended to a larger material and still needs working out exactly, because regard must still be had for the subdivision of the material.

Disregarding such clay formations as were formed *in situ*, clays may be said to arise from those watery clay suspensions which eroding rivers transported to the sea. Applying a purely colloid-chemical consideration to the process of formation of these clay suspensions it may be placed in Svedberg's class of mechanical dispersion methods. [See Stähler's Handbuch d. Arbeitsmethoden d. anorg. Chemie, Bd. IV.: I (Leipzig 1916), S. 189, etc.]. The different eroding agencies are: glacier movement, frost action, running water, which have ground the minerals, fresh or partly weathered, into so fine a powder that they were converted into more or less stable colloidal suspensions.

Clays have originated from colloidal suspensions in two ways, either by a slow sedimentation, or by more rapid coagulation set up by salts, but these processes overlap so that it is often difficult to decide whether one or the other predominates. A clay particle of $0 \cdot 3\mu$ requires 100 hours to fall 10 cms. in still water. If a clay-carrying river falls into an inlet of the sea, the bottom of which lies 10 metres below the river mouth, particles of the above size (and such are abundantly present in many clays) would require at least 14 months to reach the bottom.

The further from the mouth of the river, the smaller the particles forming the deposit. This is well exemplified in the polar sea clay deposits of Upplands (Yoldia clay). The layers correspond to the annual deposits. The thinnest layers contain only quite small particles, the thicker the layers the coarser the material, and for example in two-centimeter-layers there are only few particles smaller than $0 \cdot 5\mu$.

The so-called winter layers are considerably more highly disperse (fine-grained) than the summer layers lying below them, because in winter the streams of melted water, which carry the particles in a horizontal direction from the edge of the ice, nearly dried up and only the still floating material of the summer fell down. Thus everything agreed quite well with theoretical considerations up to a layer-thickness of about 5 cms. But then large quantities of small particles appear again, and this phenomenon troubled the author much in the beginning, and seemed to contradict the above reflections. To understand this apparent contradiction it is necessary to study the phenomena of coagulation of clay suspensions. Only when the salt content of water is relatively low does sedimentation follow exclusively the laws for movements of small particles. If the salt content exceeds a certain value, (termed "Schwellenwert"), the single particles

collect to form balls, and instead of several small primary particles there is one large secondary particle, which offers a relatively much smaller hydrodynamic resistance and therefore deposits much more rapidly. The "Schwellenwert" and the speed of balling of the particles depend on several factors. These phenomena are not yet clearly explained, but it has been provisionally shown experimentally by the author that:—(1) The "Schwellenwert" is greater for finer particles than for coarser. (2) The speed of balling of the particles (aggregation) increases greatly with the number of particles per unit volume as well as with the degree of excess of the "Schwellenwert." The speed is approximately proportional to the square of the number of particles. (3) Certain substances present in quite small quantities, called "Schutzkolloide" (or protective colloids) can hinder coagulation, or greatly increase the "Schwellenwert." Specially important for clay coagulation are here the humus substances. (4) For different salts the "Schwellenwert" are quite different. (5) Finally it is important for clay suspensions that aggregation is not only reversible but that through gentle shakings or movements within the liquid, *without removing the coagulator*, the aggregate should break up and the coagulum be again completely subdivided into primary particles. The time which is now necessary iu order to aggregate the particles again is the same as was necessary for aggregation in the beginning. As far as the author is aware, this has never been observed in other colloidal systems, but is very important for the correct understanding of clay sedimentation.

Reverting to the circumstances in the deposition of the polar sea clay, humus substances or other "Schutzkolloide" (protective colloids), which play a part for the deposition of many modern clays, could not have occurred in the glacier waters of that time. The salt content probably attained in the neighbourhood of the ice edge the "Schwellenwert" of the particles present there, that of the larger as well as of the smaller, which arises from the abundant presence of smaller particles in the thickest layers (5—9 cm. layers). But coagulation remained only partial and particularly limited on calm days, and in consequence of the surf, undulatory motion, streams of water, etc., the aggregate was now and then destroyed, in connection with which in consequence of the mingling of water free from sediment the number of particles per unit volume greatly decreased. Further removed from the mouth the salt content which might be considered approximately the same, does not attain the value requisite for the now little concentrated suspension, and the small particles can without aggregation be transported tolerably far away from the ice edge. The larger particles require a lower "Schwellenwert" and partly coagulate or gradually become deposited on the way, giving the layer formation just described. Evidently the conditions of deposition have not been in reality so schematic as was described above, layers rich and poor in salt alternated in the sea, and in particular strong currents in the sea assisted to spread the particles over far larger regions than is to be expected from only the circumstances of deposition.

The notion that sediments resting in the depths of the ocean are the finest-grained of all was a mistake, and has actually been proved to be incorrect. For such sediments as globigerina ooze and the like, which are composed particularly of shells of organisms, it is obvious that they consist of tolerably large particles, but also when the organic remains are washed out, or such a typical deep sea deposit as red deep sea clay (which is free from organisms) is examined, this is seen to be tolerably coarsely disperse. It is scarcely possible to go astray in considering these larger particles as secondary products from what were once small particles, which are synthesized under the high pressure prevailing in the depths. The author recalls the formation of glauconite grains actually observed in globigerina ooze.

That is the last phase in the history of clays—the changing of clays into new kinds of solid rocks (clay-slate, phyllite, etc), and the synthesis of new minerals. For this takes place not only in the depths of the sea, but especially where deposits are overlaid by other deposits or influenced by

eruptive masses those processes take place which are known as pressure and contact metamorphism.

TESTING OF ROOFING TILES.—B. Ganzner (*Tonind. Ztg.*, **40**, 79, 1916). The official testing of the fragility of roofing tiles is done with Marten's apparatus, the tiles being placed on a flat layer of sand, and the fragility determined according to the force of the blow exercised by the falling weight. This method is rejected by some people. It is wrong to say that the tiles are not, under ordinary circumstances, subjected to such a test, as there is hardly any test made under conditions exactly like those usually existing. The object of the test is only to arrive at a method of comparison. Tile-makers now consider that the blow should fall directly or indirectly on the top or long side of the tile, in order to estimate the fragility during transit by rail, As it has not yet been proved that the latter method gives a better result, it is useless to alter the former test. (The test is fully described in "Hilfsgerate fur Ziegeleien".)

In order to determine whether any particular tile belongs to a kind especially subject to breakage, it is customary to compare it with tiles made at various works. The fixing of a limit at which tiles may be called breakable is then discussed. The writer is in favour of the drop apparatus, but if there be conclusive reasons for so doing, the blow may fall on the top side of the tile. The limit determined by this test would probably be much the same as that of the first-mentioned method. Another test would be to place a row of tiles in juxtaposition, with the top end against a loose board. On the latter a pendulum would strike, the force of which could be measured and increased until the tiles were broken up. But in this case also, it is necessary to fix a limit up to which the tiles can be said to be breakable.

P.W.T.

III.—THE COMPOUNDING & PREPARATION OF CLAYS AND BODIES.

ELECTROTECHNICAL PORCELAIN.—(*Revue Gén. de l'Électricité*, **1**, 22, 58, 133, 180, 1917). An account of the raw materials used for body and glaze, of the processes of manufacturing (with dimensions and requisite insulating properties) numerous porcelain objects employed in the electrical industry. It refers more particularly to the products of La Chambre syndicale de la porcelaine électrotechnique.

The hard porcelain of which electrical insulators, etc., consist is produced from kaolin, clay, pegmatite, silica, felspar, and sometimes calcium carbonate. The essential constituents of these materials are silica, alumina, alkalies, and lime. The properties of the product in addition to insulating power include specific gravity about 2·25, white colour; it is sonorous, translucent, hard enough to scratch the hardest steel, impermeable to water, resistant to all acids except hydrofluoric acid, resistant to alkalies, resistant to sudden changes of temperature (60°C. for large pieces, and over 100°C for small pieces), and always has conchoidal fracture, shining, but appearing granular or silky according to the composition of the body. The glaze (when present) has always the same qualitative composition as the body. When coloured, it is by means of metallic silicates. The glaze is more fusible than the body, but is not attacked by acids or atmospheric agents, and does not crack off from the surface of the body, as all glazes of stoneware or earthenware do sooner or later.

Raw Materials. The properties of the kaolin, clay, pegmatite, silica and felspars are discussed briefly.

Composition of Body. Experience has shown 40 per cent. of theoretically pure clay substance to be the minimum. Most French and foreign porcelain bodies have an average of 5 per cent. K_2O (including the equivalent amount of Na_2O present), so it is necessary to introduce about 34 per cent. of theoretically pure orthoclase (containing 16·8 per cent. K_2O). The remaining 26 per cent. should be pure silica. Such a body is never realised practically. The actual chemical composition varies at different works according to circumstances, but when they are suitably chosen, treated, and well fired, these different bodies give appreciably equal results.

For the same insulating power, the fracture of a siliceous alkaline body, even underground and underfired, will always be granular, analogous to that of refined sugar; that of an aluminous alkaline body will always be silky, analogous to that of sugar candy.

Outside the usual materials, it may be interesting to introduce into the porcelain fusible bases other than oxides of the alkali metals.

The law of the metallic alloys is in fact applicable to ceramics: by increasing the number of bases the melting point is lowered, so in many cases lime and magnesia are added to porcelain bodies. This addition is only made in small proportions, as the fusion of alkaline earthy silicates when present in large amounts develops dangerous peculiarities.

Composition of Glaze. The porcelain glaze (often called "enamel") is made from the same components as the body, but in different proportions in order to give transparency. The fusibility of the glaze is due entirely to the increased content of felspar. The glaze has much greater hardness than the common bottle glass usually employed in the manufacture of insulators. The difference is explained by the difference in composition, for whilst the glaze contains no more than 9 or 10 per cent. of fluxing oxides (potash, soda and lime), and rather more than that percentage of alumina, glass contains more than 30 per cent. of fluxing oxides (including magnesia), and less than 5 per cent. of alumina.

The manufacture of the porcelain includes preparation of the body, preparation of the glaze, shaping of the pieces, application of the glaze, firing, and inspection or testing. Each of these processes is described, with many illustrations. The modes of shaping the pieces include pressing with comparatively dry material, and with moist material turning, gauging (forming the outer surface of the article by a mould and the inner surface with a profile), moulding (by mechanical press or by hand), and casting.

Before applying the glaze, the dried pieces are subjected to an easy firing, and after glazing they receive the full firing of hard porcelain in general. Particulars are given as to the setting in saggars. Ordinarily the glaze is not coloured, and the white tint is that of the body, showing through the transparent glaze. When colours are desired, metallic oxide is mixed with the glaze of the insulators, chromium oxide for green, iron oxide or chromate of iron for marone, cobalt oxide for blue, and uranium oxide for black. In the firing these oxides combine with free silica to form non-conducting silicates. Other colours cannot be obtained by the usual hard firing; in such cases they are applied specially in the form of a very fusible coloured enamel, which is fixed by firing in a muffle at about 900°C. The temperature attained in the ordinary glost firing varies with the composition of the porcelain but ranges between 1350° and 1450°C. In intermittent ovens or kilns, the whole time for setting to drawing is about ten days, but in continuous kilns it is about four days. The course of the firing is described in some detail.

The inspection or testing of insulators includes two examinations: the first, a simple sorting, eliminates pieces presenting defects visible to the eye; the second aims at the elimination, by means of suitable machines, of pieces the electrical or mechanical constitution of which is not suited to the use for which they were intended. The obvious defects—arising from the material, the manufacture, or the firing—are discussed at some length.

Owing to the necessity of fitting in with other articles, usually metallic, it is essential that porcelain insulators should be kept within workable limits as regards dimensions, and this is tested by measurement. Certain electrical and mechanical tests have also to be made, which are described.

MANUFACTURE OF SILICA BRICKS.—A. Valabrèque (*Cer.*, **21**, 8, 1918). A short note dealing with refractoriness and dislocation only. Silica bricks should have refractoriness such that a cone of pounded brick gives way above 1710°C. (generally between 1730° and 1750°C., Seger Cones 33 and 34). This refractoriness is realised when a brick heated to 1600°C. supports without fracture a pressure of at least 10 kg. per sq. cm. This test (devised by Le Chatelier) seems preferable to the fusion test. Silicious rocks for sufficiently refractory bricks should contain a minimum of 97 per cent. silica, and have a softening point between 1750 and 1770°C. (cones 34 and 35).

The thermal expansion of quartz is about 1 per cent. on the linear dimension from 0° to 570°C., and then increases 0·5 per cent. suddenly; above 570°C. the thermal expansion changes to a very slow contraction. The change of dimensions at 570°C. (on heating or cooling) necessitates some precautions.

The permanent expansion resulting from the change of condition of the quartz is otherwise serious. The specific gravity changes from 2·65 in the raw brick to 2·30 in a brick removed (after use) from the roof of a Siemens-Martin furnace; theoretically the volume of the brick should increase by 15·2 per cent., which would correspond to a linear expansion of 4·83 per cent. In fact, according to the nature of the rock used, the proportion of impalpable powder in the mixture and the grain sizes, the nature and amount of the fluxes, the speed of heating and duration of maximum heat, the degree of transformation effected, the respective position on the thermal scale of the formation temperature of silicates and the transformation temperature of the rock, the accumulated successive expansions will not reach 6 per cent. or will exceed 12 per cent.

Fineness of grinding appreciably reduces the expansion on heating and later expansion and allows reduction of firing temperature.

Rocks which do not fall to powder and which crack little when fragments are heated to 1450°C. are the only ones which are suitable for giving large angular grains, whose presence in the midst of impalpable powder seems indispensible for good bricks.

MANUFACTURE OF SILICA BRICKS.—A. Valabrèque (*Quarry*, **23**, 76, 1918). From *La Ceramique*. See preceding abstract.

DOLOMITE BRICKS.—L. R. (*Cer.*, **21**, 75, 1918). A short note.

PROCESS FOR MANUFACTURE OF REFRACTORY MATERIALS.—C. B. Stowe (*Cer.*, **21**, 165, 1918). Refers more particularly to magnesia refractories, and especially native magnesites. Natural magnesite is mixed with haematite, forge scales, or other form of iron oxide; the mixture is ground, and then a paste formed with water; the paste is moulded into bricks or other forms, dried and fired. The product possesses the characteristics of the mineral magnesioferrite $MgO\ Fe_2O_3$, though a single firing will not ensure formation of the mineral throughout the mass. Satisfactory material was obtained by heating for nine days a kiln charged with bricks which were afterwards left to cool five days, the temperature reached in the kiln being between those indicated by seger cones 11 and 19. It seems that the absorption of iron oxide by magnesia can be aided by maintaining a temperature between those limits for 36 to 48 hours. After this first firing the bricks are ground. The ground material is perfectly suitable as a granular product for lining the kiln. Or it can be mixed with fresh raw materials—magnesite, magnesia, or oxide of iron—to give the desired proportions in the product, and this mixture is treated in the same manner as in the process described. The smaller the proportion of iron oxide the

higher the fusion point, and the higher the proportion of iron oxide the lower the fusion point of the final refractory product, and the less friable. Hence it is well to choose for inner furnace lining a refractory material having a fusion point slightly higher than the maximum furnace temperature.

When the product is intended to be shaped into bricks, etc., a complementary treatment is recommended, which is described.

CORINDITE.—(*Cer.*, **21**, 173, 1918). A short note on a subject more fully treated in papers by Bigot and Lecesne respectively. (see previous volumes—16 and 17).

MAGNESITE AND MAGNESITE BRICKS.—(*Quarry*, **23**, 40, 1918). Abstract of paper by W. Donald. See TRANS., **17**, 486, 1918.

MANUFACTURE OF SILICA BRICKS—Philipon (*Quarry*, **23**, 47, 1918). See TRANS., **18**, Abs., 123, 1919).

SILICA BRICKS.—J. S. McDowell (*Brick*, **52**, 516, 1918). A paper presented before Section D. of the American Association for the Advancement of Science, Dec., 29, 1917. Comprising a discussion of the properties and manufacture of silica bricks, and the cause of spalling.

MANUFACTURE OF SILICA BRICKS.—(*Brick*, **52**, 1131, 1918). An illustrated description of modern methods, with special reference to the works of the Standard Refractories Co., of Claysburg, Pennsylvania, where automatic and other special applicances facilitate rapid and efficient operation. The plant includes 18 large 38-feet round down-draught kilns, which are briefly described.

AMERICAN IMPROVEMENTS IN POTTERY.—A. V. Bleininger (*Brick*, **53**, 125, 1918). A general review of progress in various directions. Reference is made to the general composition of American white ware and porcelain, and to recent improvements, to the triangular saggars used in some works, and to the Faugeron or Didier-March tunnel kiln and the Dressler kiln, etc.

CARBORUNDUM REFRACTORIES.—S. C. Linbarger (*Brick*, **53**, 705, 1918). See abstract from *J. Amer. Cer. Soc.*

CHEMICAL STONEWARE.—F. A. Whittaker (*Brick*, **53**, 875, 1918). See abstract from *J. Amer. Cer. Soc.*

POTTERY MAKING IN THE PHILIPPINES.—J. C. Witt (*Brick*, **53**, 1135, 1918). An illustrated account reprinted from the Philippine Journal of Science. Local clays and sands are used. The dried clay is pulverized and mixed with sand in the proportion of two parts clay to one of sand which has passed through a split bamboo screen of about 8 meshes per centimetre (2·54 cms=1 inch); the moistened mixture is kneaded to the desired state. Crude potters' wheels (generally wooden discs) are used. After drying-the ware is fired, either in a simple form of kiln, commonly with wood as fuel, or by piling the ware on the ground and covering it with straw, bits of bamboo, rubbish, etc., then applying a light and leaving to burn slowly until all is consumed. The temperature record of firing in an experimental kiln and that in a pile of straw at the pottery are given.

GRINDING CLAY.—(*Brick*, **53**, 1153, 1918). An illustrated account of the Ring Pulverizer used at the North Western Terra Cotta Co.'s plant in Chicago.

IMPROVEMENTS IN MANUFACTURE OF SILICA BRICKS.—C. E. Nesbitt and M. L. Bell (*Quarry*, **23**, 79, 1919). See abstract from *Proceedings of American Society for Testing Materials in* TRANS., **16**, Abs., 76, 1917.

SILICA BRICKS.—Bied (*Quarry*, **23**, 108, 1918). Abstract of paper from *Comptes rend.*, **166**, 776, 1918.

SILICA BRICKS IN OPEN-HEARTH FURNACE ROOFS.—(*The Iron Age*, **102**, No. 5—270, 1918). Translated abstracts of papers by Bied (*Comptes rend.*, **166**, 776, 1918), E. Rengade (*Comptes rend.*, **166**, 779, 1918), and Le Chatelier and Bogitch (*Comptes rend.*, **166**, 764, 1918). See separate abstracts. Rengade's paper gives reference to previous papers by Le Chatelier (alone and in conjunction with Bogitch), viz.: *Comptes rend.*, **111**, 123, 1890; **163**, 948, 1916; and **165**, 218, 1917.

REFRACTORY MATERIALS FOR COKE-OVENS.—W. C. Hancock (*Iron and Coal Trades Review*, p. 370, 1919—Sept. 10). Abstract of report of investigation on behalf of the Iron and Steel Institute. The special qualities required for materials for coke-oven construction include resistance to high and prolonged heating (under normal or increased pressure), resistance to mechanical abrasion, resistance to sudden changes of temperature, impermeability to gases, and resistance to chemical attack, especially by sodium chloride at high temperatures.

Refractories employed in coke-oven construction fall into two main classes, silica bricks and fireclay bricks. In this country the coals used for coking are washed, and contain 10 to 15 per cent. water as against 5 per cent. in coal used in the United States; hence silica bricks are not so much used here as in the States, for a more aluminous brick (fireclay) is apparently better with the higher moisture, although silica bricks conduct heat better.

The "fireclay" bricks used for coke-oven construction are generally made from a mixture of highly silicious material (like ganister), and a high-grade fireclay. It is usually considered that the silica should not be under 80 per cent., ferric oxide not over 2 per cent., alkali less than 1·3 per cent., and lime and magnesia not more than 0·5 per cent. each. Analysis of five English and four foreign coke-oven bricks show 79·29 to 84·52 silica, 13·19 to 18·68 alumina, 1·16 to 2·26 ferric oxide, and 0·11 to 1·17 potash. The mean of the published analyses collected gave 81·26 silica, 15·46 alumina, 1·47 ferric oxide, and 0·76 potash.

Fine-grained material generally is less refractory and more susceptible to chemical attack; coarse-grained material resists sudden changes of temperature better; fine-grained material seems to resist abrasion better; grain size affects porosity and permeability, and heat conductivity also according to some observers. The grain size analyses of five clays from the Stourbridge district are given.

Test pieces were made with clay and varying proportions of fine, medium, and coarse grog, mixed with water, moulded by hand, dried, and fired to about 1000°C. The clay to grog was 80 to 20, and 60 to 40 respectively. Results of tests showed that increased amounts of grog reduce the quantity of water required for moulding and also the air—and fire—shrinkage.

Abrasion seems to increase at high temperatures, and by addition of load to the wearing surfaces, and also as the firing temperature decreased. Porosity and density were also investigated. As regards permeability by gases, the finer particles give a lower value. A brief resumé relating to salty coals and their effects on coke ovens is given.

FLATTENING SLABS FOR GLASS.—(*Brick, Pot. Tr. J.*, **26**, 5, 1918). Relates to the making of the fireclay slabs or flattening plates used in converting hollow glass cylinders into flat sheets. The composition used for making the slabs and also that for a polishing paste are given.

SILICA BRICKS.—C. E. Nesbitt and M. L. Bell (*Brick, Pot. Tr. J.*, **26**, 9, 1918). See TRANS., **16**, Abs., 76, 1917. Relates to improvements in the manufacture.

ARCHITECTURAL TERRA COTTA.—(*Brick Pot. Tr. J.*, **26**, 22, 1918). A comprehensive general account.

REFRACTORY FACINGS FOR BRICKS.—(*Brick, Pot. Tr. J.*, **26**, 30, 1918). An illustrated note on Alleyne Reynolds's patent (111355) relating to facings for firebricks, stoppers, nozzles, etc.

FUSED BAUXITE.—(*Brick, Pot. Tr. J.*, **26**, 39, 1918). Relates to Lecesne's patent (No. 102507). See TRANS., **17**, 192, 1918.

MANUFACTURE OF SILICA BRICKS.—Philipon (*Brick, Pot. Tr. J.*, **26**, 54, 58, 1918). From a paper in *Comptes rend*. See TRANS., **18**, Abs., 123, 1919.

MANUFACTURE OF SILICA BRICKS.—A. Valabrèque (*Brick, Pot. Tr. J.*, **26**, 83, 1918). From *La Ceramique*. See TRANS., **19**, Abs., , 1920.

SIZE OF GROG IN FIRECLAY BODIES.—F. A. Kirkpatrick (*Brick, Pot, Tr. J.*, **26**, 151, 1918). From *Trans. Amer. Cer. Soc.*, **19**, 268, 1917 See TRANS., **17**, Abs., 69, 1918.

TREATING DOLOMITE.—(*Brick, Pot. Tr. J.*, **26**, 168, 1918). A note relating to Handy and Isham's American patents, 1,270,818 and 1,270,819. See also TRANS., **18**, Abs., 123, 1919.

MILLING OF POTTERY MATERIALS.—H. J. Plant (*Pot. Gaz.*, **43**, 44, 1918). See TRANS., **17**, 123, 1918.

HYDRAULIC SEPARATION OF FINE COALS, SHALES, AND CLAYS.—J. M. Draper (*Pot. Gaz.*, **43**, 225, 1918). See TRANS., **17**, 213, 1918.

MANUFACTURE OF SILICA BRICKS.—(*Pot. Gaz.*, **43**, 386, 1918). Translated from article by A. Valabrèque. See TRANS., **19**, Abs., 34, 1920.

SUDANESE POTTERY.—F. Stirk (*Pot. Gaz.*, **43**, 460, 1918). See also TRANS., **17**, 226, 1918.

CORINDITE.—A. Bigot (*Pot. Gaz.*, **43**, 463, 1918). Relates to fused Bauxite. See also TRANS., **17**, 267, 1918.

DENTAL PORCELAINS.—A. S. Watts (*Pot. Gaz.*, **43**, 648, 718, 1918). Reprinted from *Trans., Amer. Cer. Soc., vol.* 17.

SILICA BRICKS, ETC.—G. W. Mottram (*Pot. Gaz.*, **43**, 867, 1918). See TRANS., **18**, 148, 1919.

SILICA PRODUCTS.—A. Bigot (*Pot. Gaz.*, **43**, 868, 1918). See TRANS., **18**, 165, 1919.

RECENT DEVELOPMENTS IN CERAMICS.—A. V. Bleininger (*Claywr.*, **70**, 317, 1918). A paper read before the American Ceramic Society.

FIREPROOF COOKING VESSELS.—(*Glas-Ind.*, **29**, 202, 1918). A short note relating to a technical porcelain (produced by the Rosenthal factory) which can be used for boiling, roasting, or frying over an open fire.

MIXING DRUMS FOR DRY MATERIALS.—E. A. Küppers (*Chem. Appar.*, **5**, 65, 1918). An illustrated account of the various arrangements in use.

MEASURING APPARATUS FOR GASES, VAPOURS, LIQUIDS, AND GRANULAR MATERIAL.—F. M. Bayer (*Chem. Appar.*, **5**, 73, 89, 99, 106, 122, 129, 1918). An illustrated account of new devices gathered from the literature of patents.

SILICA PRODUCTS.—A. Bigot (*Chim-Ind.*, **1**, 194T=712, 1918). An illustrated general account of the raw materials, method of manufacture, tests, etc. See TRANS., **17**, 259, 1918, and **18**, 165, 1919.

BRICKWORKS FOR TEMPORARY NEEDS.—A. Nawrath (*Tonind. Ztg.*, **42**, 373, 391, 1918). Suggestions for meeting the abnormal demand for small and medium-sized houses by special increase in the output of bricks. Illustrations are given of bricks drying in the open, and of the firing in clamps and in annular kilns without crowns.

WASHING PROCESS FOR CLAYS AND KAOLINS—(*Toning-Ztg.*, **42**, **588**, 1918). Refers more particularly to the electro-osmosis process,

German patent 305450, which it is claimed increases the yield and the degree of dryness of clay and kaolin precipitates in the washing process, the suspension being deposited in the sol condition.

EDGE RUNNERS FOR DINAS AND OTHER SILICA BRICKS.—(*Tonind. Ztg.*, **42**, 693, 706, 722, 1918). An illustrated account of edge-runner mills used in the preparation of the silicious material, some with the motive power applied below and some above.

TECHNICAL PORCELAIN.—A. N. (*Tonwar. Ofen. Ztg.*, **42**, 6, 1918). A short article relating chiefly to laboratory porcelain and electrical porcelain.

COOKING VESSELS WITH MAJOLICA ENAMELS.—(*Tonwar. Ofen. Ztg.*, **42**, 27, 1918). A general description of the mode of preparation, etc.

STONEWARE IN THE CHEMICAL INDUSTRY.—A. Granger (*Chim-Ind.*, **1**, 35T=243, 1918). A comprehensive survey, with illustrations. For resisting the action of acids and other reagents in industrial operations, generally silicated materials have to be used, and the required conditions are met only by compact (or vitrified) pottery—stoneware and porcelain—enamelled cast-iron and quartz glass. Quartz glass is costly and rather delicate for shaping, enamelled cast-iron does not lend itself to all combinations of shape and has but a relative unchangeableness in certain cases; so that the industry in most cases disposes of hardly any but ceramic materials. Porcelain has the advantage over stoneware of perfect impermeability, being completely vitrified, whereas stoneware has only a less degree of vitrification. But porcelain is costly to make, and more difficult to shape than stoneware, and its firing presents complications.

In practice the condition of not being absorbent of liquids is not fully realised, and stoneware is met with which absorbs 0·5 to 2 per cent. water. Analyses of stonewares and stoneware clays, etc., are given. The treatment of clays and manufacture of stoneware vessels are described, including the firing, after which the properties of stoneware are briefly discussed, including a reference to Nielson and Garrow's proposals for standardization.

COMPARISON OF AMERICAN CHINA CLAYS AS PORCELAIN INGREDIENTS.—A. S. Watts (*J. Amer. Chem. Soc.*, **2**, 151, 1919). From the results of numerous tests the author concludes that the variation in the physical properties of the clays tested is worthy of serious consideration The water content for the best working plasticity is fairly constant, 23·4 to 26.1 per cent., except in the case of two bodies requiring 19.2 and 28·8 per cent. respectively. The drying shrinkage was greatest in the body containing English china clay, and so was the total shrinkage when fired to cones 7 and 10. The English china clay body was the most vitreous (and least porous) at cone 7, and also at cone 10. Curiously enough, the English china clay body showed least warpage at cone 7; at cone 10 it had about the same warpage as six other bodies, but the remaining three bodies had exceptionally low warpage at cone 10. At cone 10 (which is about the average maturing cone for American whiteware bodies), the English china clay body showed the best translucency, though at cone 7 it was seventh in order as regards that property. As regards colour, the English china clay body stood first in order at cone 7, and second at cone 10.

COMPARATIVE VALUE OF KNEADING AND PUGGING IN THE PREPARATION OF PORCELAIN BODIES.—L. E. Barringer and C. Treischel (*J. Amer. Cer. Soc.*, **2**, 306, 1919). The comparison was made with the aid of a vertical pug-mill (as used regularly in the preparation of porcelain bodies in the United States) and a kneading table (as commonly used on the Continent). Results and conclusions are as follows: Clay from the pug mill contains more air in the centre than at the edge, owing to the greater pressure where it comes in contact with the die. The centre of clay from the kneading table may or may not contain less air than the edge, according to the length of time of kneading and to the amount of water

contained in the body which is being tempered (a hard body containing less water than a soft one). Hard or medium bodies on 20-minute runs and medium bodies on 40-minute runs gave the most consistent results. The kneading table is a more efficient air-remover than the pug mill, but with a continuous kneading for 40 minutes of a hard body, air seems to be reincorporated. The kneading table seems to be most efficient on medium and hard bodies and when run for 20 minutes. The average specific gravity is higher and the average porosity lower for clay from the kneading table than for that from pug-mills.

C. F. Binns mentioned that the rolling table had been successfully used for bone china in England at a time when the pug-mill was not suitable for the purpose. The slowness of the rolling table is chiefly because the operation is not continuous. The improvement of all wares lies in the direction of the use of less plastic clays and a higher percentage of ground material. These finer bodies are not likely to be used so extensively as those of common wares, so the rolling table may find profitable use for the finer products.

C. E. Jackson stated that the drawback of kneading machines is the fact that each such machine has only about one-sixth the output of the ordinary pug-mill. The clay from the kneading machine is better in all respects than hand-wedged clay. The kneading machine strengthens a weak body, and produces a clay which works more smoothly and is better adapted for making difficult pieces. The kneading machine is much better for very delicate work, in which quality is all-important.

WASHING COAL.—W. Russell (*Pat. J.*, No. 1575, 1919). Pat. No. 122, 454, Jan. 21, 1918. A froth flotation process, such as is described in Specifications 7803/05, 2359/09, and 21857/10, is applied to the recovery of clean coal from fine dross or gum and from wash water. An agitating apparatus such as that described in Specification 6896/10 may be used. Reference is also made to the classifier described in Specification 28500/10, and to the thickeners described in Specifications 29383/10, 13606/14, and 110/188.

FILTER PRESSES.—J. A. Wilson (*Pat. J.*, No. 1577, 1919). Pat. No. 122, 979, May 22, 1918. In a plate for a filter press of the type in which a number of bars are held in a frame and support a filtering cloth, the bars are so formed that they touch each other in the centre and form on each side a set of undercut draining channels into which the Cloth will not sag. The frame may be covered with an acid-resisting material.

REFRACTORY SUBSTANCES.—G. W. Mottram (*Pat. J.*, No. 1577, 1919). Pat. No. 123,116, Nov. 7, 1917. Refractory bricks and the like are made by first dry grinding the base material and saturating it with water, then wet grinding the binder or flux to the consistency of a slip varying in fineness from 30—200 meshes to the linear inch with 1—4 times its weight of the base and mixing the product with the remainder of the saturated base material. After the mixture has been allowed to stiffen and mature and excess of water is removed, it is pressed, dried, and burned at a sintering temperature. As base material, silica, fireclay, and other old or new refractory material may be employed ground to a fineness of 8—40 meshes to the linear inch, and the clay binding material may be made more plastic by the addition of peat water or the slime deposited from the effluent from sewage purification or the refuse liquid from tanneries. Lime or other basic oxide or iron oxide or salts to the extent of 1·5 to 4 per cent. may also be added with or without 5 to 15 per cent. of fireclay. See also paper in TRANS., **18**, 148, 1919.

GRINDING OR CRUSHING.—H. Walker (*Pat. J.*, No. 1578, 1919). Pat. No. 123,259, June 25, 1918. In roller-and-ring mills for grinding or crushing, of the kind in which convex rollers are pressed by springs or the like against the concave interior face of the ring, the rollers consist of a renewable hoop, mounted on disks.

CLEANING AND ABRADING COMPOSITIONS.—Norton Co., etc. (*Pat. J.*, No. 1570, 1919). Pat. No. 121,721, July 11, 1918. To an abrasive composed of crystalline alumina containing up to 8 per cent. of an acid oxide, such as silica or titanic oxide, is added alkali, such as soda, in sufficient quantity to neutralize the acid wholly or in part. The resulting composition is stated to be less tough and more suitable as an abrasive.

EXTRUSION PRESSES FOR FILTERING.—J. W. Hinchley, etc. (*Pat. J.*, 1571, 1919). Pat. No. 121,759, Oct. 30, 1917. In treating peat and like substances in a plunger extrusion press with filtering surfaces to free them from liquid, the pressing operation is carried out at a high temperature so as to reduce the viscosity of the material treated. The pressing chambers are rectangular in cross section with perforated sides and solid tops and bottoms, and the extrusion nozzles taper vertically but not horizontally so that the material is exposed to increasing pressure in a vertical direction as it passes through the nozzles.

PLASTIC COMPOSITIONS.—C. F. Curtis (*Pat. J.*, No. 1571, 1919). Pat. No. 121, 855, Feb. 19, 1918. The dust left after burning iron, copper, or arsenical pyrites is used as an ingredient in a mixture for an acid-proof composition. The mixture is: sawdust 30 per cent., Portland cement 30, pyrites residue 30, whiting 10 per cent. The mixture is moistened and is applied as a lining or shaped by moulding.

REFRACTORY BRICKS.—C. H. Sankey and J. E. Foster (*Pat. J.*, No. 1575 1919). Pat. No. 122,388, Nov. 25, 1918. Separate portions of silicious material (consisting chiefly of silica), one in relatively coarse powder and the other in a very finely divided condition, are mixed wet with animal or vegetable fibre, or both, to form a composition for moulding. Both materials may be flint, chert stone, silica rock, quartz, sand, or stone rich in silica, calcined, and the coarser is ground to pass through any sieve of mesh from 16×16 to 100×100 per sq. inch. The fine material may or may not be calcined and will pass through a sieve of 250×250 per sq. inch. The fibre may be straw, chaff, peat, wool, hair, or the like. The mixture of the two silicious materials and fibre is mixed with water until the fibre is finely subdivided, moulded, and the articles dried and fired at a temperature above 1500°C.

REFRACTORY COMPOSITIONS.—G. Marsh (*Pat. J.*, No. 1564, 1919). Pat. No. 120,471, Dec. 3, 1917. Ground furnace slag, slate waste, infusorial earths, and similar materials in admixture with Portland, Roman, or hydraulic cement, with or without plumbago, are mixed with a solution of a proteid substance such as casein, blood, glue, gelatine. The solution may contain also sodium or potassium silicate, with or without borax, boric acid, or ammonia: The dried mixture is intended for use as a refractory material. Slate dust, slate waste, marble, granite, or similar material, mixed with Portland, Roman, or hydraulic cement, is mixed with a similar solution to form artificial slate.

WASHING COAL, COKE, ETC.—A French firm (*Pat. J.*, No. 1566, 1919). Pat. No. 120,932, Nov. 23, 1918. Apparatus for separating coke, coal or the like from slag and other heavy impurities comprises a chamber to which the coke, etc. is fed over a perforated plate, and fitted with a number of alternating horizontal plates and gaps, upward currents of water being fed to the gaps and the perforated plate. The coke, etc. passes to an outlet, while the heavy impurities fall through the gaps and are directed by the sloping bottom of the apparatus to a compartment at the rear.

CENTRIFUGAL SEPARATORS.—E. Duner (*Pat. J.*, No. 1567, 1919). Pat. No. 121,130, Nov. 27, 1918. Relates to strainer separators, the filtering surface of which consists of a number of wires stretched on a frame and so arranged that the spaces between adjacent wires increase outwardly from the axis.

GRINDING, CRUSHING, ETC.—F. W. Lyon and A. Ross (*Pat. J.*, No. 1567, 1919). Pat. No. 121,206, Dec. 22, 1917. Relates to roller and ring mills having the rollers mounted on pivoted carriers, one third to one quarter of the circumference of the ring being formed as a discharge outlet. Rotating vanes may be provided for throwing the material on to the ring, and for closing the discharge outlet.

AN AMERICAN PORCELAIN CONTAINING NO FREE SILICA.—A. S. Watts (*J. Amer. Cer. Soc.*, **2**, 488, 1919). An investigation aiming at the production of a practical porcelain body not highly sensitive to sudden change of temperature, and free from tendency to excessive warping. The body was made up of 20 per cent. Canadian felspar, 2 whiting, 33 flint, 10 Tennessee ball clay, 10 Florida kaolin, and 25 Georgia kaolin. For one set of tests the felspar, whiting, and flint were previously calcined (at cone 3) to a dense opaque mass, which was ground and mixed with the clays. The trial bodies were fired to cones 7 and 10.

It was found that by calcining or semi-fusing the fluxes and flint prior to incorporation in a porcelain body the maturing point can be lowered about two cones, the colour much improved, and the resistance to sudden temperature changes improved about 200 per cent.

Against the cost of calcining there is to be set the saving from lowering of the maturing temperature in biscuit firing, and some saving in the grinding of the felspar, which would not need to be ground so finely. If it were not desired to lower the firing temperature, the amount of flux could be reduced.

MANUFACTURE OF ABRASIVE WHEELS.—S. C. Linbarger (*J. Amer. Cer. Soc.*, **2**, 638, 1919). Relates to the bonding of abrasive wheels, the manufacture of artificial abrasives and abrasive wheels (including vitrified wheels, silicate wheels, shellac-bonded wheels). Brief reference is also made to the various purposes for which they are used.

SPECIAL SPARK-PLUG PORCELAINS.—A. V. Bleininger and F. H. Riddle (*J. Amer. Cer. Soc.*, **2**, 564, 1919). As regards electrical resistance at such temperatures as those reached in aeroplane engines, felspathic porcelains begin to break down at a rate rapidly increasing with temperature, owing to electrolytic effects. This is indicated also by the polarization which is observed in using direct current. Leakage thus takes place. The average porcelain is likewise not constant in volume, and the volumetric changes cannot be explained solely by thermal expansion. Volume changes are unavoidable in all porcelains containing free quartz in large amounts, owing to inversion between alpha and beta quartz at 570°C., and between alpha and beta cristobalite at 230°C. In a good spark-plug porcelain, the quartz should be replaced by a substance not subject to such inversions. The coefficient of thermal expansion of ordinary porcelain also varies considerably with variation of temperature, and so does mechanical strength. The method of testing spark-plug bodies is described. The resistivity of the porcelains is expressed by the "Te" value, which represents the temperature (in degrees C.) at which a c.c. of the material still shows a resistance of one megohm.

No definite relation seems to exist between composition and electrical conductivity, but the higher the maturing temperature of the porcelains the higher the "Te" value.

The remedial measures advocated are: The replacement of felspar by other fluxes, such as silicates like $MgO.Al_2O_3.2SiO_2$, or $MgO.Al_2O_3.4SiO_2$, or other silicates (natural or artificially prepared) of beryllium and the alkaline earths; also the substitution for quartz of substances not subject to inversion or other volume changes (as strongly calcined kaolin, alumina, zirconia, or natural or synthetically produced sillimanite).

With magnesia as the principal flux the electrical resistance (and hence the value "Te") increases decidedly; structure plays an important part, and magnesia greatly accelerates the crystallization of sillimanite. The texture of the body depends on number and size of the sillimanite crystals, and on

rate of cooling. Rapid cooling makes the structure closer and more vitreous, so smaller kilns (or ovens) are preferable to larger ones. The higher the firing temperature of the porcelain the greater its electrical resistance at temperatures up to about 700°C.

The mineral beryl is a valuable flux from this point of view, but careful control is necessary in firing, as beryllium porcelain is subject to sudden deformation as the vitrification temperature is exceeded. The firing temperature of these beryllium porcelain bodies is cone 11 to 12.

A very tough porcelain was made from a mixture of 45 per cent. kaolin, 17·6 felspar, 4·4 calcine ($MgO.Al_2O_3.2SiO_2$), and 33 fused alumina, Sillimanite ($Al_2O_3.SiO_2$), when not in large crystals, gives constancy in volume on heating, lowers the thermal expansion, and increases refractoriness and resistance to sudden heating and cooling. Various data are given in tables.

CONTROL OF THE SAGGAR MIXTURE.—V. S. Schory (*J. Amer. Cer. Soc.*, **2**, 747, 1919). The common method of substituting a new clay for one previously used, by inspecting fired pieces of various clays and making a selection therefrom, depends partly on judgment based on insufficient data and partly on mere guesswork, and is likely to be expensive through loss of saggars and ware. Another method is to make trials of a number of saggar mixtures in which one or more of the materials are varied, and to study the saggars made of such mixtures. A rough judgment of the quality of a saggar can doubtless be made by inspection and breaking it, but to gain accurate information it is necessary to select a number (say 25, 50, or 100 saggars) and fire them repeatedly under standard conditions, until all are broken. From the record of their behaviour a numerical expression for the quality of the saggars from a given mixture can be obtained, but the method is slow, laborious, and rather expensive. It is often necessary to make a change in the saggar mixture at short notice.

The clay content of most saggar mixtures in factories consists of one or more dense-firing or vitrifying clays and one or more open-firing and comparatively refractory clays. Sometimes a single clay or a mixture of clays of the same class is used for making saggars. The two outstanding properties of saggars are strength and refractoriness, and the aim should be to develop these properties in proportion to their relative importance in the saggar.

The author selected for comparison saggar mixtures that had been found satisfactory in use. In four of them the clay content, consisted of clays that vitrified at or below cone 11, combined with clays which after firing to cone 11 absorbed 6 to 10 per cent. of water; the clay content of one mixture consisted of two clays that burned to low absorption but were not vitrified.

From these mixtures, omitting the grog, small bars were made and fired to cone 11, the regular saggar oven heat. The absorptions in all cases were between 2·5 and 4 per cent. Similar tests with the clay content of unsatisfactory saggar mixtures—the same clays as some of the preceding but in different proportions—showed absorptions exceeding 4·5 per cent. or less than 1·5 per cent.

By experiment the proportions of each pair of saggar clays that gave mixtures firing to an absorption of about 3·25 per cent. were determined, and from these data a saggar mixture is arranged for immediately when the supply of one of the regular clays fails.

The absorption determination is also used in studying a new saggar clay. The new clay is mixed with a standard open-firing clay or a standard vitrifying clay in proportions to give about 3.25 per cent. absorption in the fired pieces. This mixture is then used as the clay content of a saggar mixture, and the average life of a saggar is found by re-firing a certain number until all are broken. This method of control of the saggar mixture is very simple, and has proved useful in practice. Individual users may obtain better results with more or less vitrification than that indicated.

FILTER PRESSES.—J. Turner, R. G. Parker, and British Dyes, Ltd. (*Pat. J.*, No. 1579, 1919). Pat. No. 123,589, Feb. 27, 1918. To facilitate

pressing the plates of a filter press together after the ordinary filtration is finished, the plates are separated by collapsible or compressible frames.

GRINDING OR CRUSHING.—H. W. Hardinge (*Pat. J.*, No. 1580, 1919). Pat. No. 123,705, Dec. 23, 1918. In tube mills having axial feed and discharge openings, coarse material is separated or trapped at the discharge opening and is returned to the feed opening by one or more conduits or conveyors which are arranged outside the mill and revolve therewith.

PULVERIZERS.—Sturtevant Mill Co., etc. (*Pat. J.*, No. 1580, 1919). Pat. No. 123,715, Oct. 21, 1918. The casing of an impact pulverizer is provided with a hollow door, arranged to render the beaters, etc., accessible for removal or repair; the grid is formed in two sections which are mounted on the casing and the door respectively, so that, on opening the door, hard obstructions, etc., fall out of the grid or can be discharged by operating the beaters.

FILTER PRESSES.—J. W. Hinchley and G. Gorton (*Pat. J.*, No. 1580, 1919). Pat. No 123,774, Nov. 24, 1916. Relates to cylinder and piston filter presses for expressing moisture from peat, fruit, vegetables, nuts, etc., and consists of means for heating an annular ring or internal device in direct contact with the sliding piston or pistons and the material by the circulation of hot fluid, or by electric heaters inserted in vertical passages in the ring, etc.

GRINDING MILLS.—O. Hagmann (*Pat. J.*, No. 1581, 1919). Pat. No. 123,991, March 1, 1919. Relates to feeding devices for roller mills.

GRINDING OR CRUSHING.—A. W. Schmidt (*Pat. J.*, No. 1581, 1919). Pat. No. 124,033, March 9, 1918. Relates to roller mills.

ARTIFICIAL CORUNDUM; REFRACTORY SUBSTANCES.—N. Lecesne (*Pat. J.*, No. 1582, 1919). Pat. No. 124,208, March 6, 1919. Addition to 102,507. See also papers by Lecesne and Bigot in TRANS. **17**, 192,267, 1918, relating to the same products (from fused bauxite).

GRADING COAL, COKE, ETC.—J. E. Yernaux (*Pat. J.*, No. 1582, 1919). Pat. No. 124,218, March 11, 1919. Relates to the use of reciprocating or oscillating sieves or screens for riddling coal, coke, limestone, etc. Also to a means of separating particles of different density by allowing them to fall upon rebounding surfaces (as metal cloths mounted in frames) arranged obliquely so that the lighter materials are projected farther than the heavier materials. This device is particularly adapted for separating coke from scoria of greater density.

GRINDING OR CRUSHING.—R. P. Park (*Pat. J.*, No. 1584, 1919). Pat. No. 124,646, June 15, 1918. Relates to mills of the kind in which rollers, working on a rotating table, are mounted to rise bodily in opposition to spring loading devices when obstructions are met, and comprises means for adjusting the spring loading devices.

BALL MILLS, ETC.—E. Newell & Co., and G. L. Woodhouse (*Pat. J.*, No. 1586, 1919). Pat. No. 124,930, April 25, 1918. Relates to compound tube-mills.

FILTER PRESSES.—W. Furness (*Pat. J.*, No. 1586, 1919). Pat. No. 124,974, June 17, 1918. A filter press plate is formed of a frame of wooden bars detachably secured together and enclosing a number of corrugated central portions of earthenware, etc., which serve to support the cloth and are so formed as to provide transverse draining channels for the escape of the liquid.

BALL MILLS, ETC.—R. C. Newhouse (*Pat. J.*, No. 1586, 1919). Pat. No. 125,012, Sept. 30, 1918. In tube mills in which the tube is of uniform diameter and is divided into compartments by a transverse partition, one of the compartments is provided with a screen which is spaced from the tube and forms a direct support for the grinding bodies.

CENTRIFUGAL SEPARATORS.—J. M. Calinand (*Pat. J.*, No. 1586, 1919). Pat. No. 125,059, March 18, 1919. Relates to a centrifugal separator the bowl of which is fitted with a number of cups nested in superposition and of such form that the space between them decreases from the centre towards the periphery.

BALL MILLS.—F. L. Smidth & Co. (*Pat. J.*, No. 1586, 1919). Pat. No. 125,064, March 25, 1919. In ball mills having a screen at the outlet, the efficiency of the mill is increased and the product is rendered more uniform by providing means for causing the crushed material to pass over the screen in a continuous path and the over-size material to return to the mill by a different path.

WASHING COAL, ORES, ETC.—J. M. Draper (*Pat. J.*, No. 1587, 1919). Pat. No. 125,344, Dec. 23, 1918. In an upward-current classifier in which the material to be treated is supplied to an inner inverted conical chamber having a downward extension, the material is fed through a hopper having a telescopic extension, whereby the point of delivery of the material to the conical chamber and its tubular extension may be varied. Reference is made to a balancing column of liquid which may be arranged as described in Specification 1849/15 or 111,826. See also paper in TRANS., **17**, 213, 1918.

CENTRIFUGAL SEPARATORS.—R. A. Sturgeon (*Pat. J.*, 1588, 1919). Pat. No. 125,502, April 16, 1918. Relates to multi-stage separators.

WASHING COAL, ETC.—W. R. Stobart (*Pat. J.*, No. 1589, 1919). Pat. No. 125,781, April 30, 1918. In an apparatus for washing coal and the like, which may be an upward-current classifier of the type described in Specification 6789/84, the washer is mounted on a weigh-bridge, the tipping of which (due to the accumulation of heavy refuse) is utilized to operate the discharging-means or to indicate when such operation is necessary.

GRINDING OR CRUSHING.—H. W. Hardinge (*Pat. J.*, No. 1590, 1919). Pat. No. 126,114, April, 26, 1918. In conical tube mills which have the axis arranged horizontally and are provided with an axial feed-inlet, a screen or barrier which extends below the level of the axial inlet is arranged in the conical outlet portion, and means is provided for removing the material as quickly as it passes through the screen or barrier. The removal of the material from the outlet side of the screen reduces the resistance and thus enables the material to pass quickly through the screen.

REFRACTORY SUBSTANCES.—Carborundum Co. (*Pat. J.*, No. 1590, 1919). Pat. No. 126,192, June 5, 1918. Silicon carbide, natural graphite in flake or granular form and a binding material such as clay are ground with water to form a mouldable mixture. The silicon carbide may be added in quantity sufficient to lesson or prevent the formation of cleavages in the moulded mass. The moulded articles are fired. In an example, the proportions by weight are: graphite 43 parts, silicon carbide 43 parts, and fireclay 14 parts.

REFRACTORY SUBSTANCES.—L. P. Kraus (*Pat. J.*, No. 1590, 1919). Pat. No. 126,229, Sept. 6, 1918. Relates to refractory products, either in loose granular form or in moulded kiln-burned shapes, for withstanding high furnace temperatures, and consists in reducing raw refractory material of a non-plastic character to a fine powder, mixing therewith a considerable proportion of ground combustible material such as ground wood and water or bonding liquids such as glucose, moulding into blocks of the desired size, and drying. The blocks are then roasted to produce clinkered material in the form of spongy grains with the cleavage planes destroyed, preferably at about 300°F. below the melting point of the material, and above roasting or calcining temperature, and are subsequently crushed if the material is required in granular form.

If bauxite is employed, the resulting product can be compressed and moulded dry without bonding material, and may be formed into bricks by

burning in kilns at a high temperature. Fluxes may be added if desired, and if binders are employed in moulding the material, any ceramic bond such as plastic clay may be chosen.

DISK MILLS.—F. E. Whitham (*Pat. J.* No. 1592, 1919). Pat. No. 126,854, July 3, 1918. The base of the rotary disk, instead of being mounted on a spindle, is mounted on balls, and is formed with a flange which fits within a flange on the casing and surrounds a pinion which is driven by another pinion on a shaft mounted in the base of the mill.

BALL AND RING MILLS.—F. L. Smidth & Co. (*Pat., J.*, No. 1593, 1919). Pat. No. 127,589, May 29, 1919. Relates to mills in which balls are located between an outer (preferably stationary) ring and an inner ring which is divided into radially movable sections carried by a rotating shaft.

ROTARY SIFTING OR SCREENING APPARATUS.—J. Thompson (*Pat. J.*, No. 1594, 1919). Pat. No. 127,783, Nov. 29, 1918. A cylindrical screen is divided into longitudinal sections by wheels fixed to a rotating shaft, and into radial sections by imperforate plates that extend from the shaft to the periphery of the screen and carry inclined vanes serving to propel the material along the screen.

PULVERIZING MACHINES.—A. E. Davis (*Pat. J.*, No. 1594, 1919). Pat. No. 128,071, Aug. 28, 1918. In impact pulverizers in which the pulverized material is delivered through a screen by suction, the pulverizing chamber is provided at one or both ends with a compartment which is divided by a screen, and a disk or shield is provided adjacent to the screen for shielding it from the direct impact of the particles; the disk may form the inner wall of the compartment.

ROLLER AND RING MILLS.—W. Chambers (*Pat. J.*, No. 1594, 1919). Pat. No. 128,107, Oct. 24, 1918. In mills in which the roller is suspended on spring-supported rods, the rods are arranged fan-wise, and guide-rollers are provided for constraining the ring.

PLASTIC COMPOSITIONS.—L. Gauthier (*Pat. J.*, No. 1597, 1919). Pat. No. 128,905, May 15, 1919. A mixture of 70-90 parts of talc and 10-30 parts of gelatine, glue, or the like, with or without colouring matter, is used for making a substitute for porcelain for electrical purposes, receptacles for perfumery and dental products, handles for knives, doors, etc. The gelatine is first softened by the aid of water and heat. After incorporation of the ingredients the product is formed into cakes which are kept wrapped in a damp cloth until ready for moulding. After moulding, the products are allowed to dry for 8-10 days, and are then polished, soaked in a 10 per cent. solution of formol, dried, and painted or varnished or soaked in sodium or potassium silicate.

PULVERIZING ROCK, ETC.—J. D. Ochterbeck (*Pat. J.*, No. 1597, 1919. Pat. No. 128,936, June 24, 1919. Relates to a machine for pulverizing large pieces of rock, etc.

REINFORCED EARTHENWARE.—F. Humphris (*Pat. J.*, No. 1598, 1919). Pat. No. 129,006, Sept. 18, 1917. Relates to the reinforcement of articles, formed of clay or clay compounds, by metal, and consists in covering the metal with a fusible glaze prior to its incorporation in the clay; also the use as a reinforcement of corrugated metal, glazed or unglazed, which may be perforated or provided with jags, barbs, furcations, dovetails, hooked projections, etc., to key with the clay, etc. The glaze, which is not fired prior to the insertion of the reinforcement, may also be applied to reinforcements of netting, perforated metal, metal frames made of rods or tubes or woven wire chains, ropes, or rings.

MAGNETIC SEPARATORS.—W. E. Poole (*Pat. J.*, No. 1598, 1919). Pat. No. 129,166, Sept. 4, 1918. The electro-magnet used in a separator is formed at its lower end with a loose pole-piece which is attracted to the body of the magnet during normal working and falls so as to act as a safety

valve when the current is stopped.

REFRACTORY SUBSTANCES.—F. H. Brooke and T. Twynam (*Pat. J.*, No. 1599, 1919). Pat. No. 129485, Aug. 7, 1918. A small percentage of fine flue dust from the down-comers of blast furnaces, containing a high percentage of magnetic oxide of iron, is added to the material used in the manufacture of acid or basic refractory bricks or blocks. For example, for making magnesite bricks, 2½-10 per cent. of flue dust is added, and for making silica bricks, ½ to 3 per cent., the amount of lime which is usually added being less than that ordinarily used. The bricks are burned in the usual way.

REFRACTORY SUBSTANCES CONTAINING SILICA.—H. M. Olson, and H. W. Becker, (*Pat. J.*, No. 1599, 1919) Pat. No. 129,505, Aug. 30, 1918. A heat-insulating material which may be rendered abrasive by calcining consists of infusorial earth or non-crystalline silica in a finely divided state and a binder including aluminium sulphate or equivalent, and an alkaline sulphate or a double sulphate of alumina or its equivalent of alkali. The composition may vary from 75 to 90 per cent. of infusorial earth and from 5 to 25 per cent. of binder. A preferable mixture consists of 88 per cent. of dry pulverized infusorial earth, 1 per cent. sodium sulphate, 1 per cent. aluminium sulphate, and 10 per cent. lime. The mixture is gauged or wetted with water and moulded into bricks, etc. The mixture may be dried and calcined at from 800° to 2700°F., forming a hard crystalline substance having abrasive qualities.

CENTRIFUGAL SEPARATORS.—W. A. Chamberlain (*Pat. J.*, 1599, 1919). Pat. No. 129,573, Jan. 23, 1919. A separator drum of double-conical form is mounted within a casing on a hollow shaft and valves for discharging the heavier separated materials are mounted within the drum, and are adjusted by means of a shaft and bell-crank levers operated from without the rotary member whilst the machine is running. The heavier constituent passes through valves to the casing.

ROTARY FILTERS.—J. A. McCaskell (*Pat. J.*, No. 1600, 1919). Pat. No. 129,905, Nov. 21, 1918. Liquids, especially slimes obtained in metallurgical processes, are filtered under pressure through a rotary drum, from the surface of which the solids are continuously removed by a scraping device provided with means for removing them from the casing containing the apparatus without loss of pressure. Means are also provided for blowing air through the filtering medium to cleanse it.

CENTRIFUGAL MACHINERY.—R. A. Sturgeon (*Pat. J.*, No. 1601, 1919). Pat. No. 130,128, July 19, 1918. A piston forms an end wall of the annular separating chamber, and by its axial movement during the continued rotation of the apparatus the solid substances are compressed and expelled. One other wall of the chamber, preferably the inner wall, is perforated to constitute a strainer through which liquid passes during the compression of the solids. Free egress for the liquid during the centrifugal separations is provided by large openings, and these are closed in the first part of the movement of the piston.

TILES, POTTERY, ETC.—J. Roberts, J. Thomas, and J. Williams (*Pat. J.*, No. 1601, 1919). Pat. No. 130,134, July 20, 1918. Tiles, bricks, sanitary ware, etc., are made from slate or shale dust, chippings, or fragments mixed with a lightening material in the form of magnesia, talc, or steatite, *e.g.*, in the proportions of 85-70 per cent. of slate or shale and 15-30 per cent. of lightening material. The materials may be mixed with water, moulded, and baked; or they may be fused, in which case 10 per cent. or more of a flux such as sodium carbonate or fluorspar may be added.

TILES, BRICKS, ETC.—V. Gastaldo, and M. Mino (*Pat. J.*, No. 1601, 1919). Pat. No. 130,135, July 22, 1918. Crushed oyster and like shells forming mother-of-pearl are mixed with a cement and moulded to form slabs, bricks, or tiles, The surface is then polished and finished with a coat of

white dammar. The shells may be placed on the surface only and may be so arranged that they form concentric rings in a mottled ground work.

WASHING COAL.—H. R. Conklin (*Pat. J.*, No. 1603, 1919). Pat. No. 130,972, July 7, 1919. Coal is separated from its heavier impurities by means of a quiescent suspension of finely ground sand or rock free from colloidal ingredients and water. The coal and a quantity of the suspension are fed to the main body of suspension contained in a separating tank, the amount of suspension supplied being sufficient to maintain a liquid overflow. The coal is removed from the surface, and the impurities are conveyed from the bottom of the tank.

MIXING APPARATUS.—C. E. Farrington (*Pat. J.*, No. 1606, 1919). Pat. No. 131,878, July 8, 1919. Consists of a revoluble stirrer which can be introduced through a bung-hole of a barrel or like container where it may be left as a fixture, or withdrawn as desired.

MIXING.—R. F. Hind (*Pat. J.*, No. 1606, 1919). Pat. No. 132,000, Aug. 20, 1918. Relates to mixing and kneading apparatus of the type in which the material is operated on by two sets of helical blades of opposite twist, and consists in using blades in short lengths so arranged that lengths of opposite twist sweep through substantially the same volume of material.

CENTRIFUGAL SEPARATORS.—R. S. Brownlow (*Pat. J.*, No. 1607, 1919). Pat. No. 132,291, June 11, 1918. Solids are discharged from the separator drum by plain or annular pistons raised by mechanical means disposed outside the drum.

BALL AND LIKE MILLS.—W. G. Watkins (*Pat. J.*, No. 1609, 1919). Pat. No. 132,985, March 25, 1919. Relates to grinding bodies of special shapes (ribbed, etc.), for use in tube mills.

REFRACTORY ARTICLES.—Carborundum Co., etc. (*Pat. J.*, No. 1609, 1919). Pat. No. 133,014, Jan. 13, 1919. Bats, saggars, and like refractory articles are made of a mixture of fireclay and carborundum grit, the major portion of which is coarser than No. 60 (60 meshes to the linear inch) and finer than No. 16, and constitutes less than 60 per cent. of the mixture. Clay grog may also be added. In a typical example, 40 per cent. each of crystalline carborundum and plastic saggar clay are mixed with 20 per cent. of clay grog obtained by crushing old saggars or calcined flint, fireclay, or the like. The articles are fired at about cone 11 (1370°C.).

CENTRIFUGAL SEPARATORS.—W. Mauss (*Pat. J.*, No. 1612, 1919). Pat. No. 133,448, Oct. 10, 1918. In centrifugal separators in which the separated solid is progressively deposited on a filter cloth through which the separated liquid passes away, the unseparated material is prevented from coming into contact with the filtering surface. The separating drum is made up of two conical members carried by a hollow shaft and a solid shaft respectively.

REFRACTORY MATERIALS.—R. D. Pike (*Pat. J.*, No. 1613, 1919). Pat. No. 133,753, Oct. 14, 1918. Magnesite is mixed with a small quantity of a deodorizer in the form of an iron alloy, such as ferro-manganese or ferro-silicon, and then heated to a temperature such as to cause a reaction reducing the total quantity of oxygen associated with the iron and more or less liberating the metallic iron. The magnesite is ground with water and with the powdered alloy and ferric oxide, and the moulded composition fired to form refractory articles. The oxide of iron may be omitted when sufficient of it occurs in the natural magnesite. Calcined magnesite can be used instead of the raw mineral, preferably with addition of the latter when making the mixture for moulding and firing.

REFRACTORY SUBSTANCES.—C. H. Sankey (*Pat. J.*, No. 1613, 1919). Pat. No. 133,842, Dec. 19, 1918. Waste refractory articles, such as fire-bricks, tiles, saggars, retorts, or the refractory lining of furnaces, kilns, flues, retorts, or coke ovens, which have been calcined in manufacture or

use, are ground and mixed with silicate of soda and water, moulded or worked by hand to the required shapes and fired. Reference has been directed by the Comptroller to Specification 376/83.

CENTRIFUGAL SEPARATORS.—R. A. Sturgeon (*Pat. J.*, No. 1614, 1919). Pat. No. 134,158, March 17, 1919. In a density separator of the type in which the separated materials are discharged by a piston moving axially within the rotating cylinder, each grade of material is compressed and ejected separately, whilst still under the action of centrifugal force, through openings in the cylinder.

REFRACTORIES IN THE ZINC INDUSTRY.—(*Mining Mag.*, **19**, 327, 1918). A fairly full abstract of paper by J. A. Audley. See TRANS., **18**, 43, 1919.

ENAMEL LINED APPARATUS.—E. P. Poste (*J. Amer. Cer. Soc.*, **2**, 944, 1919). A general account of the manufacture of vitreous enamel ware (of steel and cast iron), including the manufacture of the cast iron and steel pieces to which enamel is applied, and the preparation, application and firing of the enamels, as well as practical observations on technical control. The composition is given of several ground coats and cover coats, and numerous references to the literature of the subject, chiefly American.

BALL-MILLS.—K. Reinbold (*Tonind. Ztg.*, **40**, 102, 1916). Surprise is expressed that the advantages of the cylinder mill are so little known to brick and tile makers. The vertical runner mill, it is often said—and rightly so—grinds well moist and even wet material, although there are cylinders which are quite as good for wet grinding. With the ball-mill for dry grinding power is economised and output increased. The material to be ground should always be kept at the same level in the cylinder, and pebbles or balls be examined from time to time, so that their original weight and size may be kept up. P.W.T.

HARD ROCKS FOR COARSE POTTERY.—H. Cornelius (*Tonind. Ztg.*, **40**, 133, 1916). General remarks on the use of quarry-waste from certain rocks—granite, basalt, porphyrite, etc.—their vitrosity, softening-point, etc., for making pressed slabs. P.W.T.

INSUFFICIENT PREPARATION OF BODY FOR MOSAIC TILES. H. Kampff (*Tonind. Ztg.*, **40**, 152, 1916). An account of the wrong method of mixing the body for mosaic tiles at a certain works in Germany. P.W.T.

IV.—SHAPING AND MOULDING. DRYING.

DRYING IN CERAMICS.—G. Retgen (*Cer.*, **21**, 6, 1918). A discussion among old students of the Sèvres Ceramic School.

NEW CASTING DEVICE.—(*Brick, Pot. Tr. J.*, **26**, 5, 1918). An illustrated notice of patent 110649 (Allen and Ames).

MAKING PLASTER MOULDS.—(*Brick, Pot. Tr. J.*, **26**, 36, 1918) A short article describing the process, and pointing out precautions.

BRICK DRYERS.—(*Brick, Pot. Tr. J.*, **26**, 45, 1918). An article discussing the designing of brick dryers.

PRODUCER GAS-FIRED DRYERS.—E. J. Anderle (*Claywr.*, **69**, 436, 1918). A paper read before the fortieth annual convention of the Illinois Clay Manufacturers' Association.

CLAY PRODUCTS.—(*Brick*, **52,** 218, 1918). An illustrated descriptive article relating to the manufacture of ordinary marbles, bottles, jars, etc. It is mentioned that saggars are made by means of a sewer pipe press, which is capable of making 600 per day. Automatic jiggers are used for making the necks and bodies of bottles separately, or complete jars or other articles with no neck narrower than the body. This automatic jigger is figured, as well as an automatic machine for the lip and crown of a bottle.

ELECTRICITY FOR CLAY PLANTS.—K. C. Berney (*Brick*, **52,** 879, 1918). A discussion (with illustrations) of the suitability of electro motors for driving plant in works for making bricks, sewer pipes, pottery and ornamental tiles, and porcelain insulators.

FIREBRICKS.—(*Brick*, **53,** 369, 1918). An illustrated account of the manufacture, especially as carried on by the Crescent Refractories Co., and the Elk Fire Brick Co., both in Pennsylvania.

STANDARD SLEEVES AND NOZZLES.—(*Brick*, **53,** 882, 1918). A brief illustrated article showing proposed standard sizes for foundry ladles in the States.

RECENT DEVELOPMENTS IN CERAMICS.—A. V. Bleininger (*Brick*, **53,** 885, 1918). A brief review with special reference to the United States. The increasing use of silica bricks for by-product coke ovens is noted; the specific gravity should not exceed 2.38 and the average modulus of rupture should be about 500 pounds per sq. inch; chert and flint are transformed to cristobalite more rapidly than quartzite, but the product is weaker; sandstones are usually transformed more slowly and also tend to give weaker products.

Magnesia spinel refractories of the composition $MgO.Al_2O_3$ are mentioned. The German Klingenberg clay for crucibles has been very satisfactorily replaced both by English and American ball clays.

Allusion is made to the porcelain, chemical stoneware, optical and chemical glassware industries.

AUXILIARY FURNACE FOR DRYERS.—(*Brick*, **53,** 898, 1918). A brief note (with illustration) on a furnace used to supply a waste heat tunnel dryer when the ordinary supply runs low.

PLASTER CASTING.—T. N. (*Tonind.Ztg.*, **42,** 13, 1918). A somewhat critical review of a little book by Mayer, containing practical hints. In the book it is stated that the plaster is to be always mixed with a greater quantity of water than it can combine with chemically. The more water is added to the mixing the more porous and slower setting the casts obtained; yet in similar circumstances they can be made denser, stronger, and harder by scattering dry plaster powder on the back of the still pasty plaster casting. As average proportion can be assumed 45g. water to 100g. plaster. If the water like the plaster is measured off as needed, the plaster is scattered into the water, thoroughly stirred, but so that no air bubbles get in the paste, and left to stand two minutes. The reviewer observes that the novice at casting with plaster should be made aware that the statement of the proportion of plaster to water (100 to 45) has no claim to be considered as average proportion. The caster must immediately recognise the correct proportion when scattering in the plaster.

The book further states that suitable mixing of the plaster with water results from the plaster powder being loosened and uniformly scattered on the surface of the water, and it sinks down. This is continued until small lumps of plaster project in different places above the surface of the water. Then, and not during the scattering, it is thoroughly stirred; whereby the mass acquires the condition of thick cream. The mixing proportion between water and plaster varies according to the nature and origin of the plaster between about 10:13 and 10:17. Generally more of well-burned gypsum, which furnishes castings of good hardness, will have to be used to the same quantity of water, than of inferior plaster.

Too long stirring is detrimental to the setting process, and diminishes the hardness of the articles produced. Plaster which even with suitable treatment mixes lumpy, and becomes too thick quickly and sets, is not sufficiently burned. Such plaster gradually loses strength and keeps moist very long. Plaster which is burned too sharply hardens very slowly, but finally gets sufficient hardness if it is not absolutely dead-burned.

The mass properly mixed with water remains thinly fluid only a few minutes, then becomes pasty and sets within half-an-hour. As a sign of the finish of the setting process, it is seen when the finger nail can make in the hardened mass only slight impressions.

MOULDING MACHINES.—D. H. Bibb (*Pat. J.*, No. 1575, 1919). Pat. No. 122,608, Oct. 15, 1918. The material is fed to a pair of rollers, from a tapering hopper which has its delivery end close up to them, by a tapering screw passing right through vertically. The blade of the screw has its edge lower than its line of junction with the supporting axis.

MOULDING REFRACTORY HOLLOW-WARE.—L. Van Gulck (*Pat. J.*, No. 1577, 1919). Pat. No. 123,009, Aug. 16, 1918. A press for the manufacture of hollow refractory articles, *e.g.* condensers for zinc distillation, comprises upper and lower plates sliding upon columns and carrying respectively plungers and removable moulds, such plates being interconnected by gearing such as racks and pinions, and the lower plate being operable by hydraulic rams. The upper plate is preferably connected to balance weights. In operation, a ball of refractory material is placed in each mould, and the moulds are introduced into the lower plate. The rams are then operated to bring the plates together to mould the articles. After moulding, the hydraulic pressure is relieved and the plates separate under the influence of the balance weights. The moulds containing the moulded articles are then removed and replaced by fresh moulds.

EARTHENWARE JARS, Etc.—R. S. Brownlow (*Pat. J.*, No. 1565, 1919). Pat. No. 120,756, Nov. 12, 1917. Consists in the production of earthenware jars, etc., with an external groove, bead, screw, bayonet-joint, etc., by casting or jolleying the article in a one-piece mould having a corresponding bead, groove, etc., the dimension of which is such that the shrinkage of the article upon drying in the mould is sufficient to enable the article to clear the mould.

DRYING APPARATUS.—H. Hunter (*Pat. J.*, No. 1566, 1919). Pat. No. 120, 809, Dec. 14, 1917. A drying kiln is provided with partitions arranged near to one or more of the walls so as to form flues for the circulation of the drying gases, such partitions being hinged so as to open to give access to the heating coils, etc.

CASTING POTTERY.—H. Stevenson (*Pat. J.*, 1573, 1919). Pat. No. 122,145, Aug. 30, 1918. Plaster moulds are filled with clay slip, and carried by a conveyor to troughs into which the surplus slip from the moulds is poured by two operators, who then place the moulds on conveyors running parallel to the first, but through drying chambers; after passing through one set of drying chambers, the clay articles are removed, the empty moulds being replaced on the conveyors and carried through other drying chambers back to the filling place. The drying chambers are heated by pipes, and may be provided with exhaust fans or the like. The conveyors may be replaced by vehicles running on endless rail tracks.

SHAPING EARTHENWARE BOTTLES, Etc.—O. C. McCormick (*Pat. J.*, No. 1574, 1919). Pat. No. 122,326, Jan. 11, 1918. Relates to machines for shaping bottles, etc., from clay, etc., of the type comprising an intermittingly-rotated support carrying moulds adapted to co-operate with a vertically movable shaping tool. The whole of the mechanism is supported by a central vertical standard. The moulds are supported in carriers mounted so that they can be placed in turn under the shaping tool.

CASTING MACHINES.—W. A. Oubridge, G. Williams, and L. C. Pott (*Pat. J.*, No. 1591, 1919). Pat. No. 126,423, April 9, 1918. Relates to a centrifugal casting machine.

CASTING MACHINES.—A Canadian Firm (*Pat. J.*, No. 1594, 1919). Pat. No. 128,016, June 20, 1918. Relates to a centrifugal casting-machine for molten metal.

MOULDING POTTERY.—R. Lawton (*Pat. J.*, No. 1599, 1919). Pat. No. 129,450, July 12, 1918. Relates to jolley moulds for jars, etc., of the kind formed in separable parts, and comprises the combination with a rotatable support of a mould formed or having portions formed of halves hinged together by a pin which is carried by a rotatable part of the apparatus.

CASTING METALS, ETC.—A. W. Morris (*Pat. J.*, No. 1603, 1919). Pat. No. 130,900, July 23, 1917. Apparatus for casting metal or other materials, comprises moulds on an intermittingly rotated carrier, and a melting pot adapted to fill the moulds automatically and to be swung out of position when required, and may also have a skimming device, a press for working the casting, and an ejector, the operation being regulated if desired by a pyrometer.

EXTRUDING PLASTIC MATERIAL.—O. L. Borner (*Pat. J.*, No. 1604, 1919). Pat. No. 130,998, Aug. 7, 1919. Plastic material is extruded through a die furnished with one or more pairs of blades mounted on axles and capable of being turned transversely to the walls of the die or parallel thereto in order to produce a string of material having alternate cavities and partitions, The blades are shorter than the width of the die.

SILICA GLASS.—W. S. Quimby, and F. W. Robinson (*Pat. J.*, No. 1604, 1919). Pat. No. 131,233, Feb. 5, 1919. Relates to the forming of silica glass (or quartz glass) articles.

EXTRUDING PLASTIC MATERIAL.—O. L. Borner (*Pat. J.*, No. 1604, 1919). Pat. No. 131,291, Aug. 8, 1919. Consists in utilizing the movement of the extruded strip, issuing from the die, to operate a controlling device which governs the action of a cutting apparatus and a section-defining blade.

SHAPING METALS, ETC., IN DIES.—A. W. Morris (*Pat. J.*, No. 1605, 1919). Pat. No. 131,613, July 23, 1917. In machines for compressing metal or other material the dies or moulds are carried by a rotary table from a melting-pot, if this is used to fill them, and they are moved radially off the table into the press.

DRYING.—R. H. Wainford (*Pat. J.*, No. 1609, 1919). Pat. No. 132,948, Dec. 3, 1918. A drying stove for pottery ware comprises a double-walled chamber having pairs of upper and lower sprocket wheels over which pass continuous chains carrying ware-boards consisting of slats connected by bolts and supported at each end by braces from the bolts connecting adjacent links of the chain. Air heated by steam pipes passes upward between partitions, and is drawn away through perforated pipes and discharged outside the building.

BASALT STRUCTURES.—F. Ribble, and P. Dhe (*Pat. J.*, No. 1612, 1919). Pat. No. 133,440, Oct. 9, 1918. Molten basalt or other volcanic rock is cast in situ in successive layers to form dams, piers, barrages, fortifications, bridges, walls, foundations, etc. The space or mould to be filled is lined with bricks coated with talc or cinder, or with slabs of baked earth, cast iron, or dry cement. Coarsely crushed basalt, granite, flint, or other rock may be added to the basalt before or after casting.

BRICKS, ETC.—H. Alexander (*Pat. J.*, No. 1613, 1919). Pat. No. 133,745, Oct. 11, 1918. Sand-lime bricks, blocks, tiles, etc., are hardened by exposing them to superheated steam at a pressure of 5-10lb. per sq. inch above atmospheric pressure in hardening chambers made of ferro-concrete or the like, which may be erected in situ. The blocks, after moulding, are

placed in small wagons and wheeled into the hardening chambers and are subjected to the action of saturated low-pressure steam to effect a preliminary drying. The temperature of the steam is then raised to about the temperature of saturated steam at a pressure of 120lbs. per sq. inch., the initial low pressure being maintained to complete the hardening.

MOULDING HOLLOW-WARE.—R. B. Wragg, and W. Roulsten (*Pat. J.*, No. 1614, 1919). Pat. No. 134,093, Nov. 30, 1918. Relates to extrusion machines for making closed tubular articles.

BRICKS.—A. Ramen (*Pat. J.*, No. 1615, 1919). Pat. No. 134,387, Nov. 27, 1918. Burned bricks of ore or other material are made by introducing moulds containing the wet material on a support into a furnace, drying the material therein, removing the moulds from the material within the furnace, and burning the bricks during the remainder of their passage through the furnace.

BRICK MACHINES.—G. Hummel (*Tonind. Ztg.*, **40**, 85, 1916). Notes on the choice of a brick-machine and on the plasticity of the clays used. The wire-cut plastic machine is most used. Moulding-machine bricks usually dry more easily than wire-cut bricks. The out-put of the wire-cut machine is larger than that of the moulding machine, but the power required to drive the former is double that needed to work the latter. To-day, the mould-table machine is made by only a few firms on account of the patent, but when this has expired it is probable that this type of machine will be constructed by many engineering firms, as the bricks look like hand-made and sell better owing to their surface not being too smooth.

P.W.T.

V.—FIRING KILNS, OVENS, MUFFLES, ETC.

FLOW OF HEAT THROUGH FURNACE WALLS.—(*Brick*, **53**, 732, 1918). A short illustrated notice of the Bureau of Standards Bulletin No. 8 (under same title) by W. T. Roy and H. Kreisinger. Thermocouples were placed in different positions in the walls. It was found that the temperature fell from 1760°F. to 950° (or 810°) in passing through 7 inches of firebrick in the side wall, and that 2 inches of air space had practically no insulating value at the temperature of the experiments, doubtless owing to greatly increased radiation (which is proportional to the fourth power of the temperature).

In the arch (roof or crown) of the furnace, the temperature fell from 1380°F. to 930° (or 450°), and 1 inch of flaked asbestos had about the same insulating value as 10 inches of the brick wall.

Hence the value of a thin layer of asbestos (or still better a plaster made from kieselguhr and clay) for increasing insulation when increase of strength is unnecessary and considerable increase of weight is undesirable, as in the crown of a kiln.

STANDARD PRACTICE FOR HAND-FIRING.—R. June.—(*Brick*, **53**, 801, 1918). An article dealing with the best methods. There are two general methods of hand-firing, the spreading method and the coking method.

In the spreading method, a little coal is fired at a time, and spread evenly front to back over the fuel bed. It is good practice, in the case of a furnace with three firing doors, to bait the back half of the grate through the first and third doors and the first half through the middle door, at the same time, and at the next baiting to reverse that arrangement (the back half being baited through the middle door, etc.

In the coking method, fresh coal is fired at considerable depths at the front of the grates and when nearly or wholly coked it is pushed to the back of the furnace. The volatile matter from the green coal at the front is burned on passing over the bed of incandescent carbon at the back. This method is particularly adapted to furnaces wherein gases pass horizontally over the fire. Before each baiting the coked fuel is pushed back, leaving about one third of the grate bare, and all the green fuel is fired on the bare grate. The fire door is cracked slightly to admit air.

Modern practice inclines to the spreading method, which evidently tends to produce higher efficiency, higher CO_2, lower flue gas temperature, and more uniform steam generation—all because of greater constancy in temperature. The coking method produces less clinker. The position of the fireman, and other points, are discussed, including the smoke problem.

CLEANING SMOKE STACK.—(*Brick*, **53**, 813, 1918). When the smoke or kiln stack becomes clogged with soot, it can be safely, simply, and economically cleaned by shooting with a cannon (figured) charged with blasting powder. The procedure is described in detail.

ROUND DOWN-DRAUGHT KILNS.—(*Brick*, **53**, 912, 1918). An illustrated note explaining how to avoid cracking and inward bulging of the firebrick lining. It refers more particularly to a brick kiln.

GAS PRODUCER AS COAL SAVER.—O. L. Helfrich (*Brick*, 957, 1918). A somewhat detailed explanation of how a gas producer not only saves fuel, but also gives better control of the heat and a better quality of product.

MECHANICAL STOKERS.—R. June (*Brick*, **53**, 968, 1147, 1918). An illustrated review of the chief types of stoker.

SIGNALLING PYROMETER.—(*Brick*, **53**, 1175, 1918). An illustrated account of a Brown instrument. The temperature has been signalled in large works by lights from a certral station; there were three lights at each furnace, green for two low, white for all right, and red for too high. The white light burns normally at the furnace, but when the temperature rises or falls more than 10° from the desired temperature, the operator at the central station flashes the red or green light and extinguishes the white. To simplify the matter, the Brown signalling pyrometer automatically operates the signal lights.

LENGTH OF CONTINUOUS KILNS.—(*Cer.*, **21**, 5, 1918). A brief general discussion.

CALORIFIC YIELD OF CONTINUOUS KILNS.—Cazeneuve (*Cer.*, **21**, 74, 1918). A brief discussion of the mechanism of firing and of the causes of bad yield.

FUEL CONTROL IN METALLURGICAL FURNACES.—Sir R. Hadfield and R. J. Sarjant (*Iron and Coal Trades' Review*, p. 369, 1919 [Sept. 19]). An abstract including useful tables of comparative fuel values (of coals, cokes, and liquid and gaseous fuels), and also graphical charts of theoretical calorific intensities, etc.

REDUCING HEAT LOSSES IN KILNS.—(*Brick*, *Pot. Tr. J.*, **26**, 38, 1918). A short illustrated article pointing out how loss of heat by radiation can be checked by using kieselguhr (bricks or powder).

NEW TUNNEL OVEN.—(*Brick*, *Pot.*, *Tr. J.*, **26**, 39, 1918). Relates to C. M. Stein et Cie patent (No. 106,606) tunnel oven with regenerators, etc.

FIRING GLAZES.—A. De Gallaix (*Brick*, *Pot. Tr. J.*, **262**, 65, 1918). From *Brick*, see TRANS., **20**, Abs. 55, 1920.

COKE PRODUCER GAS FIRED TANK FURNACE FOR GLASS.—(*Brick, Pot. Tr. J.*, **26**, 100, 1918). Abstract of paper by A. B. Roxburgh. See *J. Soc. Glass Tech.*, **2**, 82, 1918.

SAVING FUEL BY CONNECTING KILNS.—(*Brick, Pot. Tr. J.*, **26**, 126, 1918). An illustrated discussion of the question, based on T. West's patent No. 115696.

TEMPORARY CONTINUOUS KILN FOR BRICKS.—(*Brick, Pot. Tr. J.*, **26**, 159, 1918). Relates to archless kilns consisting of a rectangular structure with a longitudinal central wall, with main flue and connections. A roof of wood and asbestos would form a convenient drying chamber

HINTS ON FIRING A CONTINUOUS KILN.—(*Brick Pot. Tr. J.*, **26**, 175. 1918). Relates to improved types of Hoffmann kiln for firing bricks.

DEADBURNING OF MAGNESITE AND DOLOMITE, AND BURNING OF CEMENT.—E. Steiger (*Pot. Gaz.*, **43**, 464, 1918). Refers to Steiger's patent shaft kiln with rotating bottom. See also TRANS., **17**, 250, 1918.

FUEL VALUES OF VARIOUS COALS, ETC.—O. L. Kowalke (*Claywr.*, **69**, 150, 1918). A general discussion of the fuel values of various coals, oils, and producer gases. Analyses of various American coals are given, and various comparisons of solid and other fuels.

FIRING WARES.—E. Lovejoy (*Claywr.*, **69**, 34, 153, 426, 540, 586, 640, 744, 794, 1918); also 70, 32, 80, 128, 236, 320, 360, 406, and 496, 1918. Parts 21 to 26 of a series. These parts deal with stacks, furnaces, and kilns. In vol. 70, parts 27 to 32 deal with up-draught kilns, machine handling and setting, open top continuous kilns, crowned up-draught kilns, down-draught kilns, etc.

APPLICATION OF PRODUCER GAS TO PERIODIC MUFFLE KILNS.—F. B. Ortman (*Claywr.*, **69**, 548, 1918). Abstract of paper given at fortieth annual meeting of the Illinois Clay Manufacturers' Association.

WASTE HEAT FROM CONTINUOUS KILNS.—W. D. Richardson (*Claywr.*, **69**, 648, 1918). A short article referring more particularly to brick kilns.

AUTOMATIC CONTROL AND MEASUREMENT OF HIGH TEMPERATURES.—R. P. Brown (*Claywr.*, **69**, 652, 690, 1918). Illustrated paper read before the Faraday Society. See also *Trans. Faraday Soc.*, **13**, 246, 1918.

PRODUCER GAS AND PERIODICAL KILNS.—(*Claywr.*, **69**, 760, 1918). A short note (with illustration) indicating how producer gas is adapted for firing periodical down-draught and up-draught ovens by the International Clay Machinery Co., of Drayton, Ohio.

FUEL ECONOMY IN FIRING CLAY PRODUCTS.—A. V. Bleininger and A. F. Greaves-Walker (*Claywr.*, **70**, 229, 272, 1918). Reprint of a booklet issued by the U.S. Bureau of Standards embodying hints on coal, kiln construction, setting, firing and means of controlling it, etc.

BURNING BRICKS.—M. M. Minter (*Claywr.*, **70**, 332, 1918). A short account of the Minter System of burning round down-draught kilns, which is claimed to be "the most flexible and adaptable method of burning in the world." Given good drainage it can be applied to almost any works with little interference in the operation of the plant. Each process of the burning is speeded up, and for a given capacity fewer kilns are required than of the ordinary periodic kilns. The Minter system of burning round down-draught kilns is continuous on a loop, semi-continuous on a single line, or periodical on any kiln for special ware during any part of any firing. An oxidizing or reducing atmosphere can be produced in any kiln at any time and either maintained or alternated.

PYROMETERS AND PYROMETRY.—(*Trans. Faraday Soc.*, **13**, 205, 1918). A general discussion. Brief abstracts of some of the papers (by E. F. Northrup, R. P. Brown, H. Watkin) appear in TRANS., **18**, Abs., 128, 1919.

ELECTRIC FURNACES.—(*Chemical Trade J.*, **62**, 135, 1918). A general discussion at a meeting of the Faraday Society.

FIRING GLAZES.—A. De Gallaix (*Brick*, **52**, 47, 1918). A general discussion of glost firing with special reference to coal firing. Stress is laid on the importance of the quality of the coal used. After the third stage or soaking period (following the slow fire and the hard fire), the firing is completed by lowering the temperature a little, cleaning the fire boxes, and closing the doors and ash pits well so as not to admit any air whatever.

According to the author's experience, the best way to obtain good results in the firing of glazes in up-down draught kilns (or ovens) is to fill the fire boxes with fuel at regular intervals (the higher the temperature the more frequent the baiting), to use a uniform size of coal, and to arrange each charge of the coal to form a bed of uniform thickness.

The glost firing in many American factories is severely criticised because of the irregular and generally too long intervals between the baitings, and the want of uniformity in size of the coal. The fire box is filled full of coal ranging from dust to large lumps, which results in great irregularity in burning, which may eventually affect the glazes prejudicially. The custom of filling the fire box full of fuel, which is quite permissible for biscuit firing, is very detrimental and expensive for firing glazes. Constant supervision of the firing is necessary, especially in the second stage of firing, and to get the most out of the fuel the fires should be fed oftener but with less fuel each time. Fire boxes are often left full of ashes and clinkers which interfere with the regular draught and so prevent proper combustion of the fuel, resulting in lowering of the kiln temperature and consequent delay in maturing of the glaze.

Special supervision of the firing is necessary when the kiln (or oven) begins to show red. The transition from soft to hard fire is a period of great danger and often a whole kiln of ware may be spoiled at this stage. Though the initial cost of installing an electric pyrometer is rather high, the author considers it indispensable for a good control of the gradually ascending heat.

For the third stage or finishing fire pyrometric cones are not sufficient; there should be also trial pieces glazed with some of the colours which are being fired in the kiln.

CONTROL OF KILN TEMPERATURES, ETC.—S. C. Karsen (*Brick*, **52**, 133, 1918). An article explaining the methods of using the pyrometer, draught gauge, and Orsat apparatus to control the temperatures and atmospheric conditions in kilns (and ovens). The author found the most satisfactory position for the pyrometer to be through the kiln wall between the bags and several feet above them. The advantages of this position are absence of such fluctuation as occurs when the couple is inserted in the crown of the kiln, and of the cooling action which often occurs when the couple is inserted in the kiln door; the couple is also practically secure from disturbance or breakage, and the junction between the couple and the leading wires remains fairly cool. The first step after installing the pyrometer in the best way should be to plot a curve of the firing as previously conducted, recording the temperature on the couple ((say) each hour. This should be done for several firings, and the records kept for reference so that a typical curve may be obtained. It is recommended that the whole period of firing—in the case of bricks—be divided into 6 periods, and that only one period be modified at a time. The periods are: 1, Incipient water smoking (0 to 200°F.). 2, Continued water smoking and heat raising (200° to 750°F.) 3, Rapid heat raising (750° to 1100°F.). 4, Oxidation (1100° to 1250°F.). 5, Rapid heat raising (1250° to maximum firing). 6. Vitrification or period of settle. Each of these periods is briefly discussed.

The use of the draught gauge and the Orsat apparatus is explained. It is stated that after using both draught gauge and Orsat apparatus for a time, the condition of the kiln atmosphere can be guided by the draught gauge alone.

HEAT INSULATING MATERIAL.—W. F. Schaphorst (*Brick*, **52**, 333, 1918". A discussion as to how soon will heat insulating material pay for itself. From results of elaborate experiments, the author has evolved a rule, which may be expressed thus: Multiply cost of pipe covering per lineal foot in shillings by number of British thermal units in each pound of coal, then by the efficiency of boiler, and then by 500, and divide the product by the product of (hot pipe temperature—atmospheric temperature in degrees F.) × 0·0056 1·6 and (area of metallic surface in square feet × cost of 500lb. coal in shillings) × the efficiency of the covering × (hot pipe temperature—atmospheric temperature in degrees F.). The result is the number of hours required for the covering to pay for itself. For conditions out of doors much better results than thus indicated will be obtained.

HEAT BALANCE ON A PAVING BRICK KILN.—S. C. Karsen (*Brick*, **52**, 229, 1918). The heat balance represents a complete record of the firing, and should include temperature, air, excess, amount of fuel used each day, atmospheric conditions in and out of the kiln, weight of ware set, temperature of stack gases, and all other data likely to assist in repeating. Results are given for three firings of the same kiln. The object was to obtain a better production if possible, to reduce cost of fuel per ton of ware, and to shorten the firing period. Conclusions drawn from the results were (1) That the water smoking period could not be shortened unless the bricks were very dry when set. (2) That the heat raising period could be shortened considerably. (3) That for the best results the oxidation range should not be more than 1050° to 1100°F. To burn out the core at from 1300° to 1400°F. required 110 hours, whereas at a low red heat—about 1050° or 1100°F.—36 hours less time sufficed, and at a still lower temperature a longer time was required for completion). (4) That the heat rising was best with a draught reading of 4. (5) That the temperature of vitrification was a little too high at 2050°F., and would probably have been better at 2000° to 2025°. (6) That 4 days seems sufficient to finish a kiln after the core has been oxidized out; this includes heat raising and soaking the heat at the bottom; 10 or 10½ days should be about enough for the complete firing.

The concrete results obtained were a shortening of the firing period by 1½ days (from 13 to 11½), and reduction in coal consumption of 14 tons (from 55 to 41). The time saving of 1½ days must be doubled by oxidizing the cores at the proper temperature of 1050° to 1100°F. Also more uniform results were obtained.

FLUE GASES.—(*Brick*, **52**, 237, 1918). A brief illustrated account of the method of using the Orsat apparatus, by which an analyses of flue gas may be made in a few minutes.

IMPROVED FIRING AND ECONOMY OF COAL WITH PYROMETERS.—T. M. McVay (*Brick*, **52**, 311, 335, 1918). An illustrated account of the use of pyrometers in brick kilns. It is stated that by their use a reduction of 36 hours in the firing period and a saving of 500lbs coal per thousand bricks has been effected.

DOWN DRAUGHT KILNS (FOR BRICKS).—(*Brick*, **52**, 403, 504, 1918). General discussions on the different stages of firing.

FIRING A PRODUCER-GAS-FIRED KILN.—O. L. Helfrich (*Brick*, **52**, 496, 1918). An illustrated description of the method of firing successfully.

COAL FIRING.—O. Springe (*Brick*, **52**, 510, 1918). A discussion of various types of fireboxes, and the method of firing them.

KILN CONSTRUCTION.—(*Brick*, **52**, 521, 1918). A discussion of various points, including foundation, kiln bottoms, and walls. In practice it has been found that a deep main flue gives a distinct advantage during the water-smoking period as regards good draught and freedom from water settle.

PROPER FURNACE CONSTRUCTION.—C. B. Harrop (*Brick*, **52**. 583, 1918). A discussion of important points in firebox construction, with special reference to efficiency.

KILN FOR SALT-GLAZED HOLLOW-WARE.—S. C. Karsen (*Brick*, **52**, 597, 1918). A detailed description, with complete drawings, of a 32-foot round down-draught kiln.

CONTROLLING COMBUSTION.—R. K. Hursh (*Brick*, **52**, 685, 1918). An explanation of the use of flue gas analysis for producing the best combustion, and then the use of the draught gauge to repeat these conditions. A formula for the calculation of excess air from the results of the flue gas analysis is $100 \times (100 - 4{\cdot}76 \times$ per cent. oxygen in flue gas$) = 1 +$ excess air (that is number of times that theoretically required). This formula is based on the assumption that the volume of flue gas is equal to the volume of air supplied, and gives only approximately correct results for fuels containing hydrogen.

In many cases it is not necessary to determine the oxygen in the flue gases, and a formula for excess air based on the Carbon dioxide is more desirable. For the purpose the above formula may be modified to 100 $(4{\cdot}76 \times$ per cent. carbon dioxide$) = 1 +$ excess air.

A better and more generally useful formula to be used for calculation of excess air when burning any bituminous coals is $100 \times (100/5{\cdot}5 \times$ carbon dioxide$-1) =$ per cent. excess air. The necessary excess air generally ranges from 50 to 100 per cent., and for efficient combustion the flue gases may contain 9 to 13 per cent. carbon dioxide—less may indicate too great an excess of air, and more may tend to reducing conditions through carbon monoxide.

CERAMIC BURNERS.—C. B. Harrop (*Brick*, **52**, 765, 1918). A discussion of the principles and design of oil and gas burners, with illustrations of different types, etc.

MORE WARE WITH LESS FUEL.— (*Brick*, **52**, 776, 1918). An illustrated account giving actual figures showing the advantage of using pyrometers.

FIRING WITH NATURAL GAS FOR FIREBRICKS.—C. A. Stone (*Brick*, **52**, 865, 1918). A discussion of the important factors which affect results.

FIRING WITH OIL.—F. H. Riddle (*Brick*, **52**, 951, 1918). A comprehensive article dealing with installation and operation, costs of operating, etc., and including a number of illustrations. Special reference is made to the firing of bricks, sewer pipes, and salt glazed ware.

ADAPTABILITY OF BASE METAL COUPLES. M. W. Blair (*Brick*, **52**, 960, 1918). An illustrated account of the successful application of pyrometers with base metal thermo-couple in kilns for firebricks at finishing temperatures of about 2300°F. (1260°C.). It was found that such a couple had served for 13 firings, and had cost 6¼ dollars, the material available for making another couple being about 5 dollars. The actual cost per firing was thus about 12 cents or say sixpence.

HEAT INSULATION APPLIED TO KILNS.—P. A. Boeck (*Brick*, **52**, 1139, 1918). Reference is made to several papers by American authors relating to the heat balance of kilns. It is claimed that insulation not only effects a saving in fuel consumption and reduced loss of goods, but gives more even results because of more uniform distribution of heat, better control of temperature, less cracking and air leakage in the outer brickwork, possibility of thinner walls, and avoids the necessity of overheating some

parts in order to bring others up to the temperature required. The insulation is effected by material such as the mineral "celite," consisting of nearly pure silica with cellular structure, and from which "Sil-O-Cel" bricks, etc., are made. Illustrations show how the crown and walls of kilns are to be insulated by suitable bricks and powder, by which radiation losses have been reduced from 50 to 75 per cent., and great economies and improvements effected.

WORKING POINTS OF A DRESSLER KILN.—C. A. Stone and P. Dressler (*Brick*, **53**, 33, 1918), An illustrated article in which the operation of the kiln is discussed at some length, special reference being made to the elimination of saggars, uniformity of temperature obtained, mechanical problems, etc. Advantages claimed include large savings in fuel and repairs, low temperature (about 200° to 250°C.) of the waste gases, recuperation of heat from the cooling ware, easy working, even distribution of heat, reduced losses, etc.

REDUCTION OF FIRING COSTS.—(*Brick*, **53**, 1918). An article discussing the measures needed for reducing the cost of firing. The system involves the use of monthly and other tables, the plotting of curves, etc. Several curves are given by way of illustration. Pyrometers and cones are regarded as essential. In a case quoted, it was found possible to reduce the firing period 24 hours (with corresponding saving in fuel) and to produce better ware, and it was also expected that a further 24 hours might be saved.

COMBUSTION LOSSES.—R. June (*Brick*, **53**, 465, 629, 1918). A discussion of the effects of excess air, of the various heat losses in burning coal, and of the heat balance of a boiler, furnace, also of the means available for lessening losses. The second article explains the value of various instruments—draught-gauge, CO_2 recorder, etc.

FUEL ECONOMY IN FIRING CLAY PRODUCTS.—A. V. Bleininger and A. F. Greaves Walker (*Brick*, **53**, 554, 641, 1918). An article which embodies recommendations for avoiding waste of fuel. Records of ash and water determinations are useful for comparison, and the appearance of the ash should be noted. Flat grates enable slack or fine coal to be used, so grateless furnaces and widely spaced inclined grates should only be used when the coal clinkers very badly. Haphazard admission of air is one of the most serious causes of heat loss in kilns, especially in grateless furnaces, the most effective air being that which passes through the fuel bed. Kiln crowns, being the thinnest parts, lose much heat, and it is advisable to cover them with a layer of heat insulating material, either as bricks or as a cement consisting of diatomaceous earth (Kieselguhr) with a little clay as binder. A cheaper but less efficient substitute would be bricks made of plastic clay with 25 per cent. of its weight of sawdust, and burned to the hardness of salmon bricks. In most cases about two inches of insulation will suffice. In all cases the kiln should be waterproofed by applying cement-mortar either on the insulating brick or on a flat course of bricks overlying the loose insula tion. It would be well also to insulate the walls of new kilns. Fireclay slabs held together by an iron band or by rods passing through holes make dampers which do not warp. Hinge dampers on top of the stack are most effective in controlling draught, and are much better than the usual flue damper. Imperfectly dried ware should not be set in. Practical hints for controlling the course of the firing are given.

HOW CAN SMOKE AND FURNACE GASES BE MADE HARMLESS?.—A. Th. (*Tonwar. Ofen. Ztg.*, **42**, 14, 1918). A brief general discussion. Various suggestions are made for mitigating the ill effects, including dilution of the waste gases, washing and filtering them, and treatment with electric currents.

QUARTZ AND SILICA BRICKS FOR FURNACES.—(*Tonwar. Ofen. Ztg.*, **42**, 65, 1918). A general account, with special reference to Siemens-Martin furnaces, etc.

APPARATUS FOR PULVERIZING COAL AND COKE.—A. Th. (*Tonwar. Ofen. Ztg.*, **42**, 83, 1918). A general description, without illustrations.

CARBO-COAL.—(*Tonwar. Ofen. Ztg.*, **42**, 356, 1918). A short note on Charles H. Smith's U.S. Patent process for heating pulverized coal in retorts at about 475°C., to produce gas and leave "Semi-Carbo-Coal"; this product is then mixed with pitch (from first heating also), and pressed into briquettes, which are then heated in retorts at about 980°. From a ton of coal is obtained about 9·5 kgs. ammonium sulphate, 169 cubic metres of gas in the first heating and 113 cubic metres in the second heating, about 110 litres liquids (light, medium, and heavy oils, creosote oil, and pitch), with new fuel amounting to 70 to 75 per cent. of the raw coal.

INNOVATIONS IN FURNACE ARRANGEMENTS FOR SOLID FUELS.—Pradel (*Feuerung.*, **6**, 141, 1917/18). An illustrated description of various contrivances, especially in connection with locomotive and other boilers, and including reference to the German patents of W. Lönholdt (297837), T. Limberg (299894), E. Bessert (298774), G. J. Kreussel (299332), Die Wanderrost-Werke (288931 and 300226), T. Langer (298601), Die Berlin Anhaltische Maschinenbau-Akt.-Ges. (298400), Mannstaedt & Co. (299565), Drüner and Nattenberg (299826), W. Lange (302100), J. Lange (300434), Rossa Pivoda geb. Postrihar (302021), F. Helm und R. Kaesbohrer (300977), J. Wildt (302002), E. Billig (302043), A. Hofmann (297838), and also 298792.

REDUCTION PROCESSES IN BLAST FURNACES.—Thaler (*Feuerung.*, **6**, 41, 65, 1917). A discussion, with special reference to the views of F. Wüst, Levin, W. Mathesius, etc.

VALUATION OF FUEL GAS.—D. J. Hudler *Feuerung.*, **6**, 53, 1917). A general discussion, largely theoretical, but partly based on experimental data.

THE DRAUGHT METER AND ITS VALUE IN FIRING.—A. Dosch (*Feuerung.*, **6**, 77, 93, 101, 1918). An illustrated account, with introduction and discussion.

STEAM SUPERHEATERS AND PREHEATERS.—F. Verchaue (*Feuerung.*, **6**, 109, 117, 1918). Has special reference to boiler-house working.

FACTORY CHIMNEY CALCULATIONS.—Thaler (*Feuerung.*, **6**, 125, 1918). A theoretical discussion, with application to blast furnace, etc.

STEAM JET OR UNDER-GRATE-VENTILATOR ?.—O. Nerger (*Feuerung.*, **6**, 133, 1918). A discussion of their respective merits, with special reference to boilers.

THE GAS PRODUCER—DEVELOPMENT AND PRESENT POSITION.—H. Hermanns (*Feuerung.*, **6**, 181, 189, 197, 205, 1918). An illustrated review.

A NEW PYROMETER.—(*Glas-Ind.*, **29**, 53, 1918). A short note from "Der Bergbau." The instrument consists of a tube with upper observation aperture and handle. The other aperture of the tube is placed on the piece of which the temperature is to be measured, and the colour of this piece is compared with a standard colour until complete agreement is attained. An adjustable scale shows the temperature of the piece.

RAW LIGNITE FIRING.—W. Otto (*Glas-Ind.*, **29**, 73, 1918). A short article with an illustration.

POTS AND FURNACES FOR GLASS.—(*Glas-Ind.*, **29**, 97, 1918). A brief discussion. With good clay, the mixture generally consists of half fresh and half calcined clay, but with particularly good kinds of clay, the proportions used are 2/3 calcined and 1/3 raw clay.

AUTOMATIC SMOKELESS FURNACE.—(*Glas-Ind.*, **29**, 97, 1918). A note from "The Timber Trades Journal" respecting a smokeless furnace introduced by the American Foundry Co., of Dayton, Ohio.

NEW GAS SHAFT KILN.—P. Baier (*Tonind. Ztg.*, **42**, 41, 1918). An illustrated description of a patent kiln used at a lime works at Hafslund.

SHAFT KILN (FOR LIME) WITH ARTIFICIAL DRAUGHT.—B. Block (*Tonind. Ztg.*, **42**, 98, 1918). An illustrated description. Reference is made to German patents 43901, 186855, and 227487.

CONTINUOUS TUNNEL KILN FOR HIGH GRADE CLAYWARES.—(*Tonind. Ztg.*, **42**, 159, 1918). Paper by L. E. Barringer from *Trans. Amer. Cer. Soc.*, **18**, 106, 1916. See also abstract in TRANS., **16**, 106, 1917.

TUNNEL KILN.—H. Jordt (*Tonind.Ztg.*, **42**, 427, 1918). A supplementary note to the notice of Barringer's paper above, by the grandson of P. E. Jordt, the inventor and builder of the first tunnel kiln in 1840.

THE DRAUGHT METER IN ANNULAR KILN WORKING.—R. Clausz (*Tonind. Ztg.*, **42**, 367, 1918). A short discussion.

ANNULAR KILN MANAGEMENT.—R. Seydel (*Tonind. Ztg.*, **42**, 481, 1918). Some observations on the practical working of the kiln.

THE TUNNEL KILN.—A. Nawrath (*Tonind. Ztg.*, **42**, 557, 1918). A general review. Reference is made to Bock's Prussian patent (1874), Paul Borrie and Co.'s oven (mentioned in the Handbook of Heusinger von Waldegg, 2nd Ed., 1867), and Philipp von Girard's still older Austrian patent. Also P. A. Jordt's Danish patent of 1840, and that of A. Rasch in 1854, the latter being described as probably the original of Borrie's.

HEATING SINCE THE OUTBREAK OF THE WAR.—Sarrade (*Chim-Ind.*, **1**, 51T=259, 1918). An illustrated survey, including notices of electric heating, surface combustion (Bone), heating of buildings, Rector's heating process, Bourdon's ventilation process, and domestic heating.

A BLOWPIPE WITH PREHEATED GAS AND AIR.—S. English. (*J. Soc. Glass Tech.*, **2**, 88, 1918). The rather long air tube of an ordinary blowpipe is transformed into a small electric furnace. With a suitable speed of air and gas passing through the blowpipe, the temperature of the mixture emerging from the nozzle of the burner is about 380°—400°C. The hot flame from such a blowpipe makes the working even of Jena combustion tube fairly easy, though the ordinary blowpipe flame barely softens it.

As an ordinary blowpipe is only slightly modified, the same blowpipe can still be used in the ordinary way if desired. The air jet can be changed quite easily, and thus a very hot flame of any size can be obtained from the instrument.

CRUCIBLE FURNACES.—H. N. Davis and W. R. Twigg (*Pat. J.*, No. 1517, 1919). Pat. No. 123,039, Feb. 29, 1918. In a crucible furnace fired by coal or other gas, annular reversible generators for the air surround the crucible chamber, gas being supplied alternately to the top and bottom of the crucible chamber according to which regenerator is in action for supplying air. The air and gas reversing valves may be connected so as to be reversed simultaneously.

TILTING FURNACES.—Tylor & Sons, etc. (*Pat. J.*, No. 1577, 1919). Pat. No. 123,040, Nov. 25, 1918. Relates to a tilting mechanism for a crucible furnace.

COKE OVENS.—E. Hurez (*Pat. J.*, No. 1577, 1919). Pat. No. 123,099, Feb. 6, 1919. An addition to 107,178.

GASEOUS FUEL FURNACES.—An Italian Firm (*Pat. J.*, No. 1578, 1919). Pat. No. 123,175, Feb. 18, 1918. Graphite is employed as a porous refractory material in surface-combustion processes in which a combustible gaseous mixture under pressure is employed. Fragments of graphite may

be agglomerated with tar or the like to form a porous diaphragm or structure, the volatile components being eliminated on ignition.

RETORT FURNACES.—Firth, Blakeley, Sons, & Co., and E. J. A. Shaw (*Pat. J.*, No. 1578, 1919). Pat. No. 123,408, Feb. 23, 1918. Vertical retorts are arranged in a circle or regular polygon, and are charged by means of a rotary shoot, the lower end of which moves on a circular track.

CRUCIBLE FURNACES.—T. W. Aitken (*Pat. J.*, No. 1579, 1919). Pat. No. 123,457, May 3, 1918. A tilting furnace with a horizontally arranged crucible is constructed with flow and return flues disposed horizontally about the under side and above the upper side of the crucible.

COKE OVENS.—Soc. Ch. M. Stein et Cie (*Pat. J.*, No. 1579, 1919). Pat. No. 123,527, Feb. 8, 1919. In a regenerative coke oven, arrangements are provided by which the heating can be effected either by poor gas (such as blast furnace and producer gas), or by rich gas (such as coke oven gas). In the former case both gas and air are preheated in the regenerators, and in the latter case the air only is preheated.

FURNACES AND KILNS.—H. Francart (*Pat. J.*, No. 1576, 1919). Pat. No. 122,742, March 21, 1918. A furnace or kiln for metal heating or for use in the manufacture of pottery, etc., comprises combustion and heating chambers arranged side by side and connected at top and bottom so that a continuous circulation of combustion products will take place from the combustion chamber, down through the heating chamber and back again to the combustion chamber.

ELECTRODE FURNACES. ALUMINIUM NITRIDE.—Armour Fertilizer Works and M. Shoeld (*Pat. J.*, No. 1576, 1919). Pat. Nos. 122,828 and 122,829, Jan. 6, 1919. Relates chiefly to the production of aluminium nitride.

COKING APPARATUS.—W. P. Perry (*Pat. J.*, No. 1577, 1919). Pat. No. 122,925, Feb. 14, 1918. Apparatus for the destructive distillation of carbonaceous material comprises a down-draught producer and an up-draught distilling chamber, connected at their lower parts by a conduit. The material is fed in at the upper end of each retort.

TUNNEL KILNS.—J. H. Marlow (*Pat. J.*, No. 1577, 1919). Pat. No. 122,927, Feb. 16, 1918. In a tunnel kiln of the kind in which the heating gases pass through conduits running the length of the kiln, the walls of the conduits are built up of hollow slabs, each having a number of passages or chambers therein. Each wall of the conduit is built up of two courses of slabs, laid so that the passages therein are in alignment. Each slab contains four passages, and the vertical joints between the slabs are formed by projections engaging corresponding recesses, while the joint between the courses is made by a key strip. Openings may provide communication between the passages in the slabs and the interior of the kiln, and the inner faces of the slabs may be perforated.

TUNNEL KILNS.—H. Francart (*Pat. J.*, No. 1577, 1919). Pat. No. 122,957, March 22, 1918. Retorts are mounted in chambers at the sides of the cooling zone of the kiln for the generation of gas to be used in heating the kiln. These retorts are charged with fuel, and steam or waste products of combustion are admitted to them, while they are heated by the circulation of gases from the kiln. Steam is generated in boilers mounted above the kiln in chambers through which the heated air and gases from the cooling zone are circulated under the control of adjustable valves.

ELECTRODE FURNACES.—Industrial Electric Furnace Co. (*Pat. J.*, No. 1574, 1919). Pat. No. 122,282, Feb. 1, 1918. Material is fed upwards over an inclined surface into a furnace, and escaping gases pass through the material, so that volatile metal such as zinc condensing therein runs down the surface away from the source of heat, and may be collected by a gutter.

DISTILLING COAL, ETC.—H. K. Killer (*Pat. J.*, No. 1575, 1919). Pat. No. 122,496, June 30, 1918. Oil and gas are obtained by the low-temperature distillation of various kinds of coal in shallow layers in horizontal retorts provided with louvred openings leading to gas chambers, and outlets leading to condensers, etc.

GASEOUS-FUEL FURNACES.—A. Smallwood (*Pat. J.*, No. 1575, 1919). Pat. No. 122,504, Feb. 2, 1918. Relates to a gas-fired reverberatory furnace comprising two working chambers with a single gas-producer between them, and recuperators beneath the working chambers.

NITRIDES, ETC.—A. R. Lindblad (*Pat. J.*, No. 1575, 1919). Pat. No. 122,523, Feb. 20, 1918. Nitrides of silicon, boron, aluminium, magnesium, and the like are made in an electric furnace in which one or more of the electrodes enter a free surface of the charge, which is heated by its own resistance and is removed in an unfused state at the bottom of the furnace.

EXTRACTING ZINC.—C. W. Crocker and C. Crocker (*Pat. J.*, No. 1575, 1919). Pat. No. 122,566, April 26, 1918. An extension fitted to the end of the condenser is provided internally with a removable system of baffles and has at the outer end a nozzle serving as a burner for the escaping gases.

EXTRACTING ZINC.—J. Armstrong (*Pat. J.*, No. 1576, 1919). Pat. No. 122,688, Jan. 28, 1918. Relates to a continuous process in which the zinc ore or other material, well mixed with carbon, is fed into the upper of the three sections of a retort, the smelting takes place in the middle section, and the residue (including metallic lead and iron derived from the ore, etc.) passes into the third section of the retort.

GASEOUS-FUEL FURNACES.—H. N. Davis and W. R. Twigg (*Pat. J.*, No. 1576, 1919). Pat. Nos. 122,673 and 122,674, Dec. 28, 1917. Relates to furnaces specially adapted to be fired by Coal gas (as supplied from gas works), and provided with reversible regenerators, etc.

ELECTRIC FURNACES.—C. W. Kayser and J. E. Robinson (*Pat. J.*, No. 1573, 1919). Pat. No. 122,034, Jan. 12, 1918. An electrode-holder comprises a frame and extension, both made with passages for water circulation, the extension serving to protect a device for adjusting a bearing plate, which co-operates with other plates either backed by replaceable packings or mounted so as to rock. The adjusting device for the bearing plate may comprise screws, cams, eccentrics, levers, wedges, or springs.

CHARGING ZINC RETORTS, ETC.—Edgar Zinc Co. (*Pat. J.*, No. 1573, 1919). Pat. No. 122,119, June 4, 1918. In a retort-charging machine, the action of the apparatus is controlled by the amount of material fed into the retort. A machine more especially adapted for charging zinc retorts, comprises a range of cylinders with tapered heads, which, when the apparatus is in charging position, enter and close the mouths of the retorts.

ELECTRIC FURNACES, ETC.—C. Petersen (*Pat. J.*, No. 1574, 1919). Pat. No. 122,173, Dec. 30, 1918. Current is generated by forcing gases to rotate in a magnetic field, and may be utilized externally or may effect reactions in the gases. Oscillatory currents, for wireless signalling and the like, may be produced.

ELECTRIC FURNACES.—U. Magini (*Pat. J.*, No. 1574, 1919). Pat. No. 122,175, Dec. 31, 1918. An arc is guided by "ionizing material," such as carbonaceous or graphite material, either granular or in the form of plates, slabs, bricks, bars, cylinders, or the like, or of rammed tar material. The material may have cavities or recesses occupied by the arc. The furnace may take the form of a reverberatory furnace suitable for pottery, tempering, hardening, annealing, drying, distilling, etc. It may also be made suitable for melting metal powder, quartz, glass, etc., etc.

GAS MANUFACTURE.—C. F. Broadhead (*Pat. J.*, No. 1574, 1919). Pat. No. 122,179, Jan. 2, 1919. In the manufacture of mixed coal gas and water

gas, a vertical retort is surrounded by chequer brickwork, and the whole contained in an outer shell.

ELECTRIC FURNACES.—V. F. Turner and J. Walker (*Pat. J.*, No. 1568, 1919). Pat. No. 121,409, March 6, 1918. Relates to mechanism connecting an electrode to a regulating motor, including a ratchet-clutch closed by a spring which prevents damage if the descending electrode encounters an obstruction, the friction of the clutch being sufficient to transmit motion during normal descent. Manual adjustment of the electrode is very rarely necessary with the arrangement described.

COKING, ETC.—Oil Extractors, Ltd., and F. Lamplough (*Pat. J.*, No. 1569, 1919). Pat. No. 121,496, Oct. 16, 1917. Coal is distilled in the presence of steam which is supplied from a generator with a water supply under a head free to rise and fall so that the height of the head regulates the pressure of the steam, and generation of steam ceases when the pressure is sufficient to drive the water out of the generator. The steam generator may be heated by the hot gases formed in the retorts, and may be fed by a feed-water heater similarly heated.

ELECTRODE FURNACES.—Watson & Co., H. A. Greaves and H. Etchells (*Pat. J.*, No. 1569, 1919). Pat. No. 121,563, April 18, 1918. Two upper electrodes or groups, and a conducting hearth or third electrode, are connected to three delta-grouped transformer secondaries, the transformer primaries being Y-connected to a three-phase supply circuit, and the ratios of transformation being such that, with a predetermined value of the hearth resistance, the supply circuit is symmetrically loaded for power and for power factor when the upper electrodes are conveying equal currents.

GAS MANUFACTURE.—Drakes, Ltd. and J. W. Drake (*Pat. J.*, No. 1572, 1919). Pat. No. 121,975, Oct. 4, 1917. Gas retorts are combined with producers in such a way that the plant will produce either coal gas, water gas, producer gas, or any desired combination of these, the coal gas retorts being heated by the combustion of gases formed in the producers, or simply by the heat of these gases. The retorts may be supplied with coke, and water gas may be produced by passing steam through the heated coke.

COKE OVENS.—B. Zwillinger (*Pat. J.*, 1567, 1919). Pat. No. 121,085, June 17, 1918. Bee-hive coke ovens of ordinary form are converted into by-product ovens by providing heating flues beneath the floor, and an air-preheater with its necessary connections external to the structure of the ovens.

FEEDING PULVERULENT FUEL, ETC.—W. O. Renkin (*Pat. J.*, No. 1567, 1919), Pat. No. 121,135, Nov. 29, 1918. Relates to apparatus for feeding pulverulent fuel and other materials, and comprises means for regulating the feed and for ensuring uniform delivery.

GAS MANUFACTURE.—J. Walster and S. Walster (*Pat. J.*, No. 1567, 1919.) Pat. No. 121,146, May 24, 1918. Coal gas is formed from powdered coal, which is fed in the form of a cloud or fog to an electrically or gas-heated retort, which may also be heated by the exhaust gases of an internal-combustion engine to which the gas is fed, the retort being suitably lagged and protected.

POTTERY KILNS, ETC.—J. S. Maddock and W. E. Maddock (*Pat. J.*, No. 1567, 1919). Pat. No. 121,198, Dec. 13, 1918. A gas-fired pottery or like kiln of the tower type is constructed with an inner hollow wall or lining containing air and heat passages or flues communicating with the combustion chamber, and forming a central vertical bore or passage for the goods, which are passed through it, preferably from below upwards, out of contact with the heating gases. An expansible ring is provided at the base of the central bore to support the shelves for the goods.

FIRING POTTERY, TILES, ETC.—A. Fielding (*Pat. J.*, No. 1568, 1919). Pat. No. 121,251, May 2, 1918. Relates to carriers for supporting pottery, tiles, etc., during firing, and comprises pillars formed with holes to pegs adapted to support shelves or bats at any desired height. The shelves are formed with holes to pass over the pillars.

ELECTRIC FURNACES.—Soc. Electro-metallurgique Française (*Pat. J.*, No. 1568, 1919). Pat. No. 121,282, Nov. 29, 1918. A current-conducting electrode-holder has radial projections engaging in transverse holes in the electrode. The arrangement is particularly applicable to electrodes consisting of bundles of rods, and to block electrodes.

ELECTRODE FURNACES.—C. H. Vom Baur (*Pat. J.*, No. 1564, 1919). Pat. No. 120,444, Nov. 10, 1917. Two-phase current is supplied to three pendent electrodes, arranged in a furnace of oval shape in plan such that the distance of each electrode from the walls is proportional to the current traversing it.

COKING, ETC.—S. Glover and W. Wild (*Pat. J.*, No. 1564, 1919). Pat. No. 120,458, Nov. 20, 1917. Coking furnaces are fitted with superheating devices heated by the waste flue gases and adapted to deliver superheated steam or gas to the centre of the charge to assist in the coking of the charge and to increase the volume of gas formed.

PULVERULENT-FUEL FURNACES.—H. Batchelor (*Pat.* J., No. 1564, 1919). Pat. No. 120,522, May 17, 1918. Finely powdered coal dust and heated air are mixed together in predetermined proportions, according to an analytical determination of the carbon and hydrogen content of the coal, and the mixture is then discharged continuously into a combustion chamber in the presence of heat. From the mixing chamber, the mixture passes beneath the grate on which a mass of refractory material is supported. At starting, the mixture is ignited by a burner placed below the grate.

DISTILLING ZINC.—E. S. Berglund (*Pat. J.*, No. 1564, 1919). Pat. No. 120,549, July 26, 1918. In order to obtain as much liquid zinc as possible in zinc-distillation processes, the zinc dust deposited in the condenser is subjected to a rubbing action and to compression by means of a screw mounted to rotate in the bottom of the condenser. The zinc dust is forced by the screw through an opening which may constitute the condenser outlet, a receptacle being placed to receive the molten zinc. The amount of compression and the duration of the pressure may be adjusted by varying the pitch of the screw and the extent to which the screw enters the opening.

LIQUID-FUEL FURNACES.—A. M. Aubert (*Pat. J.*, No. 1564, 1919). Pat. No. 120,559, Oct. 10, 1918. Relates to a tilting furnace having reversible regenerators at the ends.

DISTILLATION OF COAL.—C. H. Smith (*Pat. J.*, No. 1580, 1919). Pats. Nos. 123,738 and 123,739, Feb. 17, 1919. In the first, caking coals, and coals of high volatile content, are finely divided and subjected to distillation at 800° to 950°F. in a retort or oven, the porous carbonaceous residue being transferred to a producer and converted into producer gas or water gas and ammonia at 1500° to 1800°F. The second patent relates to a combined furnace and retort for the treatment of coal, the retort being built up of hollow-tiles arranged to form combustion flues. The apparatus is worked continuously, the coal being moved from the charging to the discharging end by blades on two paralled rotating shafts, so spaced that their blades overlap.

ELECTRIC FURNACES.—W. J. Howard (*Pat. J.*, No. 1581, 1919). Pat. No. 123,845, March 13, 1918. Relates to a device for automatic adjustment of the regulating mechanism in electrode furnaces.

CARBON ELECTRODES.—E. Ridoni, etc. (*Pat. J.* No. 1581, 1919). Pat. No. 123,972, Aug. 28, 1918. Electrodes are made by purifying natural graphite and moulding it, preferably hot, with a binder which may be tar

or pitch. A part of the impurities may be left in to serve as a binder—as quartz or silicates from which may be formed amorphous silica, and this gives rise to carborundum when the electrode is used in a furnace.

CARBONIZING OR DISTILLING APPARATUS.—N. H. Freeman (*Pat. J.*, No. 1581, 1919). Pat. No. 124,015, Feb. 12, 1918. Coal or the like is carbonized in a series of chambers arranged in tiers and adapted to heat the material at different temperatures, the by-products being led away separately from each chamber by outlets.

CARBONIZING APPARATUS.—G. T. Beilby (*Pat. J.*, No. 1581, 1919). Pat. No. 124,039, March 12, 1918. Coal or other bituminous or organic material to be carbonized is spread in a thin layer on trays carried round horizontally by a rotating frame within a gas-tight casing. The casing is enclosed within a larger chamber, and is supported in such a manner that the products of combustion of the heating burners, which are arranged to render the inner surface of the dome of the chamber incandescent, may have access to the whole of its surface.

ELECTRIC FURNACES.—S. C. Hazard, and H. S. Morris (*Pat. J.*, No. 1581, 1919). Pat. No. 124,116, June 4, 1918. Relates to electrodes having screw sockets in their ends.

CHARGING RETORTS.—Soc. du Four vertical continu (*Pat. J.*, No. 1582, 1919). Pat. No. 124,199, March 3, 1919. In vertical ovens or retorts which are worked semi-continuously, and in which the sealing of the ovens at the upper end is effected solely by the pulverulent material of the charge, a ram is provided for compressing the charge and forcing it regularly down the ovens, the ram being of such size and shape that it can enter the oven or an upward extension thereof.

DISTILLING COAL, ETC.—J. Nelson (*Pat. J.*, No. 1583, 1919). Pat. No. 124,231, Dec. 21, 1917. Coals of various kinds such as shales, bitumens, and oil sand, peat, etc., are distilled at 350-450°C. and in the presence of vapours and gases obtained by cracking hydrocarbon oils, or the gases obtained by separating the condensable hydrocarbons therefrom, and, if desired, with the addition of superheated steam.

COKING, ETC.—R. J. Rew (*Pat. J.*, No. 1583, 1919). Pat. No. 124,247, Feb. 25, 1918. For manufacturing water gas in horizontal coking ovens, to mix with the coal gas obtained by coking, superheaters are arranged in the retort setting or in the retort itself.

DISTILLATION OF COAL.—F. Lamplough, and Oil Extractors, Ltd. (*Pat. J.*, No. 1583, 1919). Pat. No. 124,294, March 28, 1918. Coal in a still is preheated by hot gases from a furnace until volatile products commence to be given off, and is then subjected to the action of superheated steam sprayed into the furnace and is passed (with or without the furnace gases) through a chequer-work superheater. The volatile products are thus carried off with the steam from which they are separated later. Steam may then be cut off and the temperature of the still raised sufficiently for the material therein to be burned to form carbon monoxide by raising the temperature of the furnace, steam being again introduced at the higher temperature and the volatile products so obtained, comprising ammonia and carbon monoxide, conducted away separately from those obtained at the lower temperature. The second heating may be effected in a second still.

LIQUID FUEL FURNACES.—General Engineering Co., Detroit (*Pat. J.*, No. 1583, 1919). Pat. No. 124,303, April 5, 1918. A completely combustible mixture of fuel and air is projected into, and caused to assume a vortex movement within a shallow flame chamber the walls of which are inturned at the top to form a baffle flange.

EXTRACTING ZINC.—C. Crocker, and C. W. Crocker (*Pat. J.*, No. 1584, 1919). Pat. No. 124,621, May 4, 1918. In the manufacture of zinc and

zinc dust by distillation, sodium carbonate or soda-ash is used in the charge in place of the common salt usually employed.

ELECTRIC FURNACES.—J. Bibby (*Pat. J.*, No. 1587, 1919). Pat. No. 125,179, Sept. 2, 1918. Relates to means for preventing leakage through the gap in a roof around an electrode.

RETORT FURNACES.—A. J. Toogood, and R. Dempster & Sons (*Pat. J.*, No. 1587, 1919). Pat. No. 125,189, March 11, 1918. In a bench setting for gas retorts, the gas and air are delivered vertically into the combustion space to form vertical flames along the sides of the retorts.

ELECTRODE FURNACES,—R. Steiger (*Pat. J.*, No. 1587, 1919). *Pat.* No. 125,391, April 7, 1919. In a furnace having at least one upper electrode for each phase of a supply system, and one or more hearth electrodes, energetic heating of the body of molten material is produced, when required, by switching out or raising one upper electrode and replacing it by the hearth electrodes, which are connected to the same point of the supply system. When surface heating of a quiescent bath is required, arcs are formed from all the upper electrodes, and the hearth electrodes may be either left in circuit or switched out. The hearth electrodes may be covered with resistance material.

FURNACES AND KILNS.—A. Tilstone, and T. Tilstone (*Pat. J.*, No. 1588, 1919. Pat. No. 125,486, March 14, 1918. A heat regulator for ovens and kilns for firing pottery and the like consists of a detachable "grid" or perforated block or set of blocks which are fitted to the outlet and other flues of the kiln, etc., to check the flow of gases. Reference has been directed by the Comptroller to Specification 4610/91.

CARBONIZATION OF COAL, ETC.—R. J. Rew (*Pat. J.*, No. 1588, 1919). Pat. No. 125,496, April 13, 1918. Relates to horizontal or inclined retorts in which superheated steam is introduced, preferably during the final stages of carbonization. Specification 124,247 is referred to.

ELECTRODE FURNACES.—C. C. Gow, and D. F. Campbell (*Pat. J.*, No. 1588, 1919). Pat. No. 125,522, May 11, 1918. An electrode is adjusted by fluid pressure controlled by an electro-magnetic device receiving from a source independent of the furnace current, a current which is regulated automatically by a varying resistance in accordance with the power taken by the furnace.

ELECTRODE FURNACES.—H. Coates, H. J. Norballe, and Watford Electric and Manufacturing Co. (*Pat. J.*, No. 1590, 1919). Pat. No. 126,113, April 26, 1918. Relates to arrangements for adjusting.

VERTICAL GAS RETORTS.—F. J. Bancroft and J. B. Hansford (*Pat. J.*, No. 1590, 1919). Pat. No. 126,121, April 27, 1918. In gas retorts of the vertical type in which the coal, etc., is charged into the lower end and forced upwards by a power-actuated device, the gases being withdrawn from the lower end, definite quantities of air or oxygen and steam or water are introduced at the top of the retort and pass down through the hottest zone where the water-gas reaction takes place. The hot gases generated descend through the incoming coal and are withdrawn at the bottom of the retort, which is the coldest zone.

COKE OVENS.—A. Belgian Firm (*Pat. J.*, No. 1590, 1919). Pat. No. 126,180, May 23, 1918. Each heating wall is divided by a vertical partition into two symmetrical sets of flues, each of which comprises a vertical flue at the middle of the oven and horizontal flues connected in series. There are two regenerators (reversible), and combustion is controlled by dampers in some of the flues.

TUNNEL KILNS.—Dressler Tunnel Ovens, Ltd., and H. J. Rushton (*Pat. J.*, 1590, 1919). Pat. No. 126,218, Aug. 8, 1918. Relates to a tunnel kiln or oven, for firing bricks, pottery, etc., in which a single com-

bustion or heating chamber is arranged longitudinally in the middle of the oven with the goods-carrying trucks at the sides. The goods-carrying platforms of the trucks are arranged at or about the level of the top of the combustion chamber, and beneath them are passages (which increase in depth towards the combustion chamber) through which heated air circulates after contact with the walls of the combustion chamber.

ROTARY KILNS.—N. Winqvist (*Pat. J.*, No. 1590, 1919). Pat. No. 126,230, Sept. 9, 1918. The preparatory heating zone of a rotary cement kiln is provided with internal projections which present to the material only edges in the direction of rotation, so as to avoid carrying the material with them during their rotation. The rest of the kiln is provided with solid annular projections.

LIQUID FUEL FURNACES.—W. M. Burdon (*Pat. J.*, No. 1590, 1919. Pat. No. 126,319, Dec. 9, 1916. A liquid-fuel furnace is made with a primary combustion chamber separated from the melting chamber or bath by a wall or bridge which has an inclined face to deflect upwards the gases from the burner.

AIR, ETC., HEATING FURNACES.—A. C. Ionides (*Pat. J.*, No. 1591, 1919). Pat. No. 126,477, May, 11, 1918. A gas-fired apparatus for heating air and other gaseous fluids consists of a tubular member which leads combustion products from a combustion chamber at its upper end to a discharge outlet at a lower level; the tube or tubular member is enclosed in a duct through which the gas to be heated passes in a contrary direction.

RETORT FURNACES.—C. H. Smith (*Pat. J.*, No. 1591, 1919). Pat. No. 126,614, April 17, 1919. Relates to "furnace retorts" or ovens more particularly adapted for the partial carbonization of coal, and comprises modifications in the setting and heating arrangements, in means for agitating and conveying the charge within the retort, and in the discharging apparatus.

FURNACES—CRUSHING, DRYING, ETC., OF FUEL.—Quigley Furnace Specialities Co. (*Pat. J.*, No. 1591, 1919). Pat. No. 126,638, May 7, 1919. Apparatus for preparing pulverulent fuel and conveying it to furnaces for combustion therein comprises means for crushing, drying, and pulverizing coal, which is afterwards fed by pneumatic apparatus to pulverulent fuel burners located in the firing openings of the furnaces.

ELECTRODE FURNACES.—Industrial Electric Furnace Co. (*Pat. J.*, No. 1592, 1919). Pat. No. 127,131, June 20, 1918. A tilting furnace is constructed so that it can only be charged after removing a roof traversed by one or more electrodes, the connections of which are not disturbed by the removal.

COKE OVENS.—O. Piette, etc. (*Pat. J.*, No. 1592, 1919). Pat. No. 127,165, Aug. 22, 1918. In a coke oven with reversible regenerators, each unit of which comprises two connected tunnels (of different sizes), the air supplied to the regenerators is preheated in flues situated between the smaller tunnels and the bottoms of the ovens and in the foundations beneath the regenerators. These flues prevent overheating of the structure, and more particularly of the upper parts of the tunnels, where the outflowing gases are coolest.

GAS MANUFACTURE.—R. & J. Dempster, and J. M. Ballingall (*Pat. J.*, No. 1592, 1919). Pat. No. 127,179, Oct. 14, 1918. The producer is connected with both the scrubber and the chimney by a dust-arrester of the kind described in Specification 116,876, wherein the gases, whether in blowing or producing, have to pass through a screen of water falling from a central dome under a water pipe.

COKING.—L. Wilputte (*Pat. J.*, No. 1593, 1919). Pat. No. 127,554, Feb. 7, 1919. In coke ovens having elongated horizontal coking chambers with doors closing the ends, in which the metallic framework forms the sides of the frames for the doors, the flash-plates are provided with outwardly

extending flanges to form (together with a lateral rib of the door) a narrow groove into which luting material is packed. The flanges also provide protection to the adjacent metalwork against burning gases issuing through faults in the luting.

COKE OVENS.—A Paris Firm (*Pat. J.*, No. 1593, 1919). Pat. No. 127,590, May 29, 1919. Reversible regenerators arranged in pairs beneath ovens with horizontal coking chambers are adapted to be worked in parallel, either both for air, or one for air and one for gas, according to the nature of the gas employed.

EXTRACTING LEAD AND ZINC.—F. E. Elmore (*Pat. J.*, No. 1593, 1919). Pat. No. 127,641, May 8, 1917. Lead and zinc are extracted and separated from ores, concentrates, and the like, in which these metals occur together as sulphides, by heating with an acid agent which converts the lead into a soluble compound, whilst the zinc sulphide remains substantially unattacked. The acid agents used are sulphuric acid alone, or a solution of a suitable salt to which has been added either sulphuric acid, hydrochloric acid, or an alkali bisulphate. Suitable salts are sodium chloride, ammonium chloride, or other halogen salt (not of a heavy metal) capable, in solution, of dissolving lead sulphate or chloride.

ELECTRIC FURNACES.—Watson & Co., H. A. Greaves, and H. Etchells (*Pat. J.*, No. 1593, 1919). Pat. No. 127,661, May 16, 1917. Relates to a water-cooled sleeve surrounding (just outside the furnace) an electrode passing through a furnace wall or roof.

RETORTS.—J. A. Yeadon (*Pat. J.*, No. 1594, 1919). Pat. No. 127,986, June 12, 1918. Vertical gas retorts are corrugated throughout their length. Several earlier specifications are referred to.

TUNNEL KILNS.—C. H. Zwermann (*Pat. J.*, No. 1594, 1919). Pat. No. 128,180, Oct. 1, 1918. A kiln comprises two tunnels, side by side, through which the goods pass in opposite directions, the common wall being provided near the ends with vertical flues in communication with the tunnels at top and bottom. Circulation of air through these flues effects transfer of heat from the cooling zone of one tunnel to the preheating-zone of the other. The fire places are arranged in the outer walls at the middle of the length of the kiln, and the products of combustion enter the tunnels through perforated baffle walls, and are withdrawn through ports into a flue which communicates with a jacket-flue around each tunnel near the charging end. In a modification, the kiln is fired by gas.

FURNACES, GAS PRODUCERS, ETC.—R. Colombo, J. Cazaban and M. F. Fernandez (*Pat. J.*, No. 1595, 1919). Pat. No. 128,375, June 17, 1918. A furnace or fire-box, adapted also for generating gas for power, lighting, or heating, consists of a plain self-contained fuel-container into which fuel such as saw-dust, coal dust, or household offal, is packed round a central perforated tube, or round a removable rod or bar. The fuel in the central passage is lighted by means of alcohol or the like; a removable cover is then applied, and the air inlet regulator (at the bottom) and the outlet regulator (at the top) are adjusted until a smokeless flame is produced. When the outlet regulator is closed, gas is generated which may be conducted by pipes to a lamp or to a motor.

FURNACES.—M. Mathy (*Pat. J.*, No. 1597, 1919). Pat. No. 128,874, Feb. 22, 1919. Relates to tilting crucible furnaces.

ELECTRODE FURNACES.—General Electric Co. (*Pat. J.*, No. 1598, 1919). Pat. No. 129,014, Sept. 20, 1917. A hearth is screened by a low wall from direct radiation from arcs between one or more pendent electrodes and a conductor situated on the base near the wall.

ELECTRIC FURNACES.—Spear & Jackson, and G. Marriott (*Pat. J.*, No. 1598, 1919). Pat. No. 129,027, Sept. 27, 1917. Relates to an electrode-holder.

ELECTRODE FURNACES.—General Electric Co. (*Pat. J.*, No. 1598, 1919). Pat. No. 129,039, Oct. 2, 1917. Relates to a multiple-electrode furnace which is provided with regulating devices that tend to maintain constant current in one arc and constant pressure across another arc.

RETORTS.—J. West, and W. Wild (*Pat. J.*, No. 1598, 1919). Pat. No. 129,139, July 17, 1918. Horizontal and inclined retorts for the continuous destructive distillation of coal and the like, such as of the type described in Specification 113,981, in which the feed is effected by a plunger which forces the material through the retort, are formed substantially wedge-shape in cross-section. The sides may taper over their full depth or over a part of their depth, and are preferably curved. The retorts may be tapered in their length. Specification 123,441 is also referred to.

FURNACES.—Fuel Saving Co. (*Pat. J.*, No. 1598, 1919). Pat. No. 129,199, Nov. 27, 1918. Apparatus for feeding pulverized coal to furnaces, of the type comprising one or more pairs of closely adjacent screw-conveyors, is provided with means for supplying an air blast about the forward ends of the conveyors to carry the fuel to the furnace.

FURNACES.—Fuel Saving Co. (*Pat. J.*, No. 1599, 1919). Pat. No. 129,395, April 15, 1918. Relates to apparatus for feeding pulverulent fuel to locomotive fireboxes, and for burning it therein.

COKE OVENS.—J. Marr, W. Colquhoun, and Coke Oven Construction Co.—(*Pat. J.*, No. 1599, 1919). Pats. Nos. 129,432 and 129,433, July 9, 1918. Relate to coke ovens with horizontal flues.

ELECTRIC FURNACES.—Morgan Crucible Co. and C. W. Speirs (*Pat. J.*, No. 1600, 1919). Pat. No. 129,760, June 14, 1918. The circular container of a resistance furnace is of conducting material and has integral with it three extensions fitted with water-cooled terminals for the supply of three-phase current. The container is moulded from a mixture of graphite and clay; it may be lined with clay, bauxite, zirconia, or carborundum, and may have a spout or tapping-hole. It is enclosed in a lined metal casing, which may be arranged to tilt. An arch or roof may be provided.

FURNACES.—G. H. Roberts and W. N. Booth (*Pat. J.*, No. 1600, 1919). Pat. No. 129,830, Jan. 27, 1919. In a furnace of the type in which the outer walls are separated from the walls of the heating chamber by a space through which the waste gases circulate before passing to recuperators, the recuperators are situated in a flue below the furnace and surrounded by the outer walls. The waste gases flow in the opposite direction to that of the air or gas, or both, being heated.

COKE OVENS.—A Paris Firm (*Pat. J.*, No. 1600, 1919). Pat. No. 129,994, July 16, 1919. In a vertical-flued regenerative coke oven in which the direction of flow of the heating gases is reversed in groups of flues along the heating wall, the flues in the two halves of each group are connected to regenerator compartments under adjacent ovens.

COKING.—G. W. Wallace (*Pat. J.*, 1600, 1919). Pat. No. 129,997, July 16, 1919. In the destructive distillation of carbonaceous materials, the gases evolved are caused to travel through the coolest part of the material, and together with the oils, are immediately withdrawn from the retort.

ELECTRIC FURNACES.—H. Coates and Watford Electric and Manufacturing Co. (*Pat. J.*, 1601, 1919). Pat. No. 130,020, Dec. 19, 1917. In combination with an automatic arc-furnace regulator controlled in accordance with the current strength, there is employed a pressure-controlled switch which in its normal position permits the usual operation of the regulator, but, when the pressure falls abnormally low, modifies the action of the regulator or substitutes other means so that the arc is lengthened more rapidly by a continuous movement. Tripping of the circuit-breaker of the furnace is thus prevented, and hand regulation of the electrodes at

starting is rendered unnecessary. If current is cut off from the furnace, the electrode is raised until stopped by a limit switch.

RETORT FURNACES.—T. Phillips (*Pat. J.*, No. 1601, 1919). Pat. No. 130,175, Aug. 8, 1918. In a mechanical retort of the kind comprising two superposed chambers separated by a heating flue, an additional flue is provided above the upper chamber communicating at one end with the heating flue and at the other with the chimney.

ELECTRIC FURNACES.—J. R. Hoyle, and P. W. Fawcett (*Pat. J.*, No. 1601, 1919). Pat. No. 130,205, Sept. 20, 1918. A conical shield for an electrode is in two or more parts, resting at their upper ends against the electrode, and at their lower ends on a base around the opening in the furnace roof through which the electrode passes.

ELECTRIC FURNACES.—G. Marriott (*Pat. J.*, No. 1601, 1919). Pat. No. 130,288, March 3, 1919. A hearth comprises a layer of fine dolomite and tar, a covering of asbestos millboard extending partly up the sides and around the doors and spout, and a copper or bronze plate with a tail piece extending through the wall to which a supply conductor is connected; the metal plate is surrounded by slightly higher magnesite bricks, and is covered with graphite powder to the level of the bricks. A single course of magnesite bricks is built round the sides. Within the shell thus formed is packed a bed (about 12 inches thick) composed of 60 per cent. dolomite, 30 magnesite, 8 fine metal clippings, 2 per cent. graphite, with a binding of tar. above this is packed a second bed (6 inches thick) similar to the former one, except that there is 10 per cent. metal clippings and no graphite. Above this are sloping sides composed of 60 dolomite and 40 magnesite. The upper walls are built of silica bricks resting on a layer of fine chrome ore.

ELECTRODE FURNACES.—C. C. Gow (*Pat. J.*, No. 1603, 1919). Pat. No. 130,687, March 14, 1918. To check escape of hot gas, an electrode is closely surrounded by a sleeve which rests on an annular seating free to slide in any direction on the furnace casing or on an interposed part such as a water-cooled box. The sleeve may be of metal, preferably ribbed, or of refractory material having good thermal conductivity, as a mixture of fireclay and graphite.

ELECTRODE FURNACES.—British Thomson-Houston Co., and J. J. Ash (*Pat. J.*, No. 1603, 1919). Pat. No. 130,703, March 19, 1918. In a poly-phase furnace, each electrode is adjusted by a device under control of two solenoids or the like, one responding to change of current in the phase, and the other being connected between the electrode and the hearth or an artificial neutral point, so that adjustment can only take place when the current and pressure change in opposite directions.

MUFFLE FURNACES AND KILNS.—J. H. Marlow (*Pat. J.*, No. 1603, 1919). Pat. No. 130,708, May 4, 1918. In a kiln or oven for the manufacture of pottery, tiles, etc., the lining is formed of multitubular slabs arranged to provide continuous passages extending over the arch of the kiln; each slab being corrugated or fluted on both faces, and being formed to make joint with the slabs above and below, and also to interlock or joint with retaining-blocks built into the walls of the kiln. The slabs may form a wall between the flues for the heating gases and the interior of the kiln, or the continuous passages previously mentioned may themselves form the heating flues. In the former case, perforations may be provided in the inner faces of the slabs to allow circulation of hot air through the continuous passages and the kiln chamber.

GAS MANUFACTURE.—R. M. Simpson, and G. R. Hislops (*Pat. J.*, No. 1603, 1919). Pat. No. 130,796, Aug. 17, 1918. Steam is admitted to horizontal gas retorts for the production of water gas through a steam pipe which extends through a chamber arranged longitudinally beneath, and exterior to the retort.

COKE OVENS.—A Paris Firm (*Pat. J.*, No. 1603, 1919). Pat. No. 130,974, July 22, 1919. In a vertical-flued coke oven having reversible regenerators running longitudinally beneath the ovens, the sets of vertical flues are connected to regenerator compartments beneath the ovens on both sides of the heating wall.

RESISTANCE FURNACES.—J. A. Fleming (*Pat. J.*, No. 1604, 1919). Pat. No. 131,061, April 9, 1918. A heating wire is hung in free loops from supports on the furnace wall, which has high heat-insulating power. The wire may be of nichrome, of uniform section and resistance, and without joints. It is slightly spaced from the wall. Short-circuiting may be prevented by distance-pieces of fused quartz, alundum or diatomaceous brick. The loops may be supported by iron or copper lugs or strips, or by notched projecting bricks. They may be arranged in series or parallel, or for polyphase currents. The wall may be of fireclay, silica, or diatomaceous bricks, surrounded by slag wool in a brick or iron cylinder; or a very thick wall of diatomaceous brick may be surrounded by stock or firebricks. A door or lid is made of asbestos, or diatomaceous brick, with an aperture for inspection and for a pyrometer.

SHAFT KILNS.—T. Hodson (*Pat. J.*, No. 1604, 1919). Pat. No. 131,095, May 7, 1918. Relates to kilns for dolomites, limes, cements, etc., having one or more incinerating chambers with the smallest cross-sectional area. The cross-sectional area becomes gradually enlarged upwards, and also downwards to a maximum after reaching which it remains constant.

DISTILLATION, ETC., OF CARBONACEOUS MATERIALS.—W. E. Davies (*Pat. J.*, No. 1604, 1919). Pat. No. 131,105, July 3, 1918. In the distillation, gasification, and the like, of carbonaceous materials, gases or vapours introduced into the chambers or retorts, or mixed with the products withdrawn therefrom, are exposed at the place of introduction, or just previously, to contact with electrodes at a potential suitable for ionization of the gases or vapours. In the case of carbonization, gases substantially free from uncombined oxygen are used, such as products of combustion, producer gas, blast furnace gas, hydrogen, steam, hydrocarbon vapour, carbon dioxide or monoxide, and nitrogen. When applied to a gas-producer, the gases used contain the necessary free oxygen. Mineral dust or the like may be introduced with the gases.

FURNACES AND KILNS.—C. Candlot (*Pat. J.*, No. 1604, 1919). Pat. No. 131,269, Nov. 12, 1918. Addition to 119,235. Relates to conical discharging members.

ELECTRIC FURNACES.—P. F. Sarron, and J. Simon (*Pat. J.*, No. 1605, 1919). Pat. No. 131,372, May 27, 1918. Relates to a converter having laterally placed electrodes, with or without hearth electrodes.

GAS RETORTS, ETC.—H. J. Toogood, and R. Dempster & Sons (*Pat. J.*, No. 1605, 1919). Pat. No. 131,409, July 16, 1918. In the distillation of coal, intermittingly-charged retorts in direct valveless communication are worked in groups so that the gas formed by admitting steam to a retort, in which the process of distillation is completed and the coke raised to incandescence, passes directly into a retort or retorts charged with coal from which the moisture has been driven off.

ELECTRIC FURNACES.—General Electric Co. (*Pat. J.*, No. 1606, 1919). Pat. No. 131,767, Sept. 20, 1918. A regulator responding to changes in the current or pressure in a furnace is also controlled automatically in accordance with the temperature of the furnace, so that when the furnace or charge is cold, the regulator maintains a larger power input.

TUNNEL FURNACES.—A. Bigot (*Pat. J.*, No. 1607, 1919). Pat. No. 132,069, Sept. 19, 1918. In a tunnel furnace for the high temperature treatment of metals, chemical products, glassware, pottery, etc., the tunnel structure is double walled with an intermediate filling of non-conducting

material, and the moving parts, such as the supporting-plates for the goods, and the balls on which they run, are made of highly refractory substances. Fused bauxite, corundum, and alumina, carborundum, compounds of chromium, magnesium, and the rare earths such as the oxides of zirconium, cerium, and the like, are mentioned as suitable. The two walls of the tunnel structure are connected by cross walls of small thickness, and the filling may be powdered magnesia, silica, and the like, or material in agglomerate form.

ELECTRIC FURNACES.—J. Simon, and P. F. Sarron (*Pat. J.*, No. 1607, 1919). Pat. No. 132,080, Sept. 24, 1918. Gases are heated by passage through channels in a moulded resistance body of carborundum and graphite, or through silica tubes embedded in a granular mixture of these substances. The resistance body may be surrounded successively by carborundum firebrick and a sheet-iron casing; when the resistance is granular the carborundum lining may be omitted. The application in superheating the blast for blast furnaces, etc., is described.

ELECTRODE FURNACES.—T. H. Watson & Co., H. A. Greaves, and H. Etchells (*Pat. J.*, No. 1607, 1919). Pat. No. 132,081, Sept. 25, 1918. Relates to modifications of the arrangements described in Specifications 106,626 and 121,563.

PYROMETERS.—Kelvin, Bottomley, and Baird, and C. H. Wright (*Pat. J.*, No. 1607, 1919). Pat. No. 132,132, Dec. 5, 1918). Relates to a form of thermo-electric pyrometer.

OIL-FIRED FURNACES.—Brayshaw Furnaces & Tools, Ltd., and S. N. Brayshaw (*Pat. J.*, 1607, 1919). Pat. No. 132,421, Dec. 30, 1918. An oil-fired furnace is constructed with an L-shaped combustion chamber, to which oil is supplied by an injector or burner. Specifications 110,960 and 119,817 are referred to.

ELECTRODE FURNACES.—W. E. Moore (*Pat. J.*, No. 1607, 1919). Pat. No. 132,436, Feb. 13, 1919. Relates to an adjustable charging device.

RETORTS.—C. H. Smith (*Pat. J.*, No. 1607, 1919). Pat. No. 132,487,, April 16, 1919. A retort of inverted heart-shaped cross-section is formed of "caloized" steel plates, namely, steel plates which have been heated for about 10 hours in contact with powdered aluminium at a temperature of 1800°F.

COAL-CARBONIZING APPARATUS, ETC.—H. L. Doherty (*Pat. J.*, No. 1607, 1919). Pats. Nos. 132,488 and 132,489, May 10, 1919. Relates to a process and apparatus for producing water gas and carbonizing coal.

GAS MANUFACTURE.—A. J. Liversedge, and W. B. Davidson (*Pat. J.*, No. 1608, 1919). Pat. No. 132,586, Aug. 27, 1918. Relates to apparatus for separating suspended matter (tar, etc.) from gas by centrifugal action.

ELECTRODE FURNACES.—E. L. Crosby (*Pat. J.*, No. 1609, 1919). Pat. No. 132,879, Sept. 25, 1918. Relates to rotary or oscillating cylindrical furnaces.

ELECTRIC FURNACES.—General Electric Co. (*Pat. J.*, No. 1610, 1919). Pat. No. 133,026, Aug. 6, 1919. Relates to furnaces for heating large objects.

POTTERY KILNS (OR OVENS). H. Webster (*Pat. J.*, No. 1610, 1919). Pat. No. 133,128, Sept. 25, 1918. A kiln (or oven) for burning pottery and other clay products comprises two parallel lines of chambers, having between them a main flue, the corresponding end chambers of the two lines being connected by underground flues, and a roofed superstructure which serves for the reception and storage of coal is provided over each line of chambers. Solid walls separate the chambers, and placed near these are perforated walls. The side wall fireplaces are arranged in pairs on both

sides of the wicket openings on opposite sides of each chamber, and deliver into the chamber through semi-cylindrical bags, secondary air being supplied within the bags from flues running through the side walls and beneath the ash-pits. The gases pass down through openings in the chamber floors to sub-floor flues, and are delivered thence either to the main flue through a dampered connection or to the next chamber of the series, which they enter from the space between the solid and perforated walls. The front end chamber of each line is also provided with fireplaces delivering into the space between the end wall and the adjacent perforated wall, and fuel may be fed through openings in the roof and burned amongst the bricks or in the spaces between the solid and perforated walls. When a muffle is built inside a kiln chamber, the bags are dispensed with, and the products of combustion are led to the sub-floor flues through vertical flues passing through the muffle.

CHARGING RETORTS.—J. G. W. Aldridge, and T. J. Ashley (*Pat. J.*, No. 1611, 1919). Pat. No. 133,380, Aug. 9, 1918. A push-plate charger for gas-retorts is provided with an auxiliary ram or stop capable of being advanced by the charging-member into the mouth of the retort towards the end of the charging stroke to push up the last portion of the charge, and held in that position during the return stroke to prevent the withdrawal of the coal, being finally retracted and held automatically in the retracted position until again required to move forward.

GAS MANUFACTURE.—G. J. Jackson, and Woodall & Duckham (*Pat. J.*, No. 1613, 1919). Pat. No. 133,730, Sept. 10, 1918. Vertical gas retorts are provided with means for injecting oil into a heated flue, which may form part of the setting of the retorts, and from which the vaporized oil passes into the gas.

FURNACES.—M. Mathy (*Pat. J.*, No. 1613, 1919). Pat. No. 133,889, Feb. 26, 1919. In gaseous fuel furnaces in which combustion of a gaseous mixture is effected in a mass of granular refractory material, the size of the fragments of refractory material is varied at certain parts of the furnace where it is desired to obtain a variation in the temperature, the higher the temperature required at any particular part of the furnace the smaller the size of the fragments of material used. To obtain uniform temperature throughout the furnace, the fragments of refractory material decrease in size from the entrance to the exit of the combustible mixture.

ELECTRODE FURNACES.—M. R. Trembour (*Pat. J.*, No. 1613, 1919). Pat. No. 133,954, Oct. 13, 1919. A melting hearth, of curved section and elliptical or similar shape in plan, directly supports a removable low arched roof which forms arched doorways at the narrow ends of the furnace. Electrodes pass through the roof in a single row along the major axis or in two rows near the axis. In the latter case, the middle electrodes are in contact with the charge, while the outer ones are thereto.

DISTILLING COAL, ETC.—F. M. Perkin, and Nitrogen Products & Carbide Co. (*Pat. J.*, No. 1614, 1919). Pat. No. 134,236, Feb. 19, 1918. Apparatus for the destructive distillation of coal and other carbonaceous material, in which inert gas or highly superheated steam is passed through the material during the carbonizing process, comprises a number of inclined or vertical retorts of refractory material with passages or channels in the walls of the retorts for the passage and superheating of the steam to be employed.

DRYING, HEATING, AND COOLING APPARATUS.—Dressler Tunnel Ovens, Ltd., and J. Williamson (*Pat. J.*, No. 1614, 1919). Pat. No. 134,332, Nov. 1, 1918. A continuous kiln for heating or drying goods in an atmosphere free from combustion products comprises a longitudinal passage containing an air heater, and a second passage above the first and communicating directly with its upper part and through a return passage or passages in the walls with its lower part, and supporting a carrier by which

the goods are conveyed continuously through the apparatus, the air circulating continuously between the two passages. Preliminary drying is effected by the passage of moderately heated air through the goods in one part of the apparatus, this air being discharged from the upper part; air entering the apparatus is used to cool the finished goods.

GAS MANUFACTURE.—N. Young (*Pat. J.*, No. 1615, 1919). Pat. No. 134,529, Oct. 15, 1919. The low temperature distillation of coal is effected in rotary inclined retorts which may be heated externally or internally or both, and the waste gases from blast furnaces, coke ovens, and producers can be utilized for heating.

GRATES WITH PREHEATED AIR OF COMBUSTION.—(*Tonind. Ztg.*, **40**, 86, 1916).

VI.—GLAZES AND GLAZING. ENAMELS.

GAS WORKS AND COKE OVENS.—C. Berthelot (*Chim-Ind.*, **1**, 107T =471, 1918). A discussion of the feasibility of combining the two, with illustrations.

ENGOBE GLAZES.—(*Tonind. Ztg.*, **42**, 482, 615, 1918). Two brief notes.

THE GLAZING OF PORCELAIN.—(*Tonwar. Ofen. Ztg.*, **42**, 15, 1918). A short note. The porcelain objects are glazed—after a first firing at a comparatively low temperature—by dipping them in the glaze, and then firing at 1330° to 1530°C. The first firing is necessary because otherwise the thin-walled vessels when dipped in the fluid glaze would disintegrate.

Schamberger (in "Keramische Praxis") recommends for glaze trials to start with 10 parts felspar, 7 parts calcspar (or $CaCO_3$), 8 parts calcined quartz and 2 to 3 parts kaolin. The mixture should be very finely ground, and used in about the consistency of thick milk (after passing through a fine sieve). The dipping should not take place too slowly, because the very porous vessel eagerly absorbs the liquid and thus favours the formation of too thick a layer of glaze.

If the fired trial shows crazing, more quartz must be used. Running of the glaze is combated by addition of kaolin and quartz, whilst if the glaze should not flow readily enough more felspar is to be added.

When the correct composition of the glaze has been found, a greater quantity of glaze is prepared and a longer series of trials made with pieces of various shapes before beginning regular use on a large scale.

EARTHENWARE GLAZES.—(*Tonwar Ofen. Ztg.*, **42**, 134, 1918). A short general account of leadless glazes free from boric oxide.

NEW COLD GLAZE.—(*Glas-Ind.*, **29**, 22, 1918). According to Karl Friedrich of Breslau, articles of clay, cement, and concrete, natural stones and other building materials may be supplied with a glaze without heating, which sets well, adheres firmly, possesses fine lustre, and can be applied easily and quickly even on very large surfaces. The glaze consisting of very finely divided substances capable of setting is mixed with water, which contains a small addition of bituminous substances (free from volatile oils), oxidized in presence of alkalies, especially "Zeresit"; it is applied by spraying with air pressure, and after about eight days the glaze has set thoroughly. Tests have shown that cement slabs glazed in the cold by this process are strongly resistant to frost, boiling water, heating, alcohol, alkali, and oil; that under the action of ammonia and concentrated sulphuric acid the colour, but not the glaze itself, suffers; the glaze is attacked only by hydrochloric, nitric, and hydrofluoric acids. Accordingly the Friedrich

process can be used advantageously as a substitute for fired glazes for clay-wares and building materials, and the cheapness of the process makes it particularly suitable for surfaces of masonry, cornices, pillars, door and window frames, etc.

THE RELATIVE ACTION OF ACIDS ON ENAMELS—III.—E. P. Poste (*J. Amer. Cer. Soc.*, **2**, 32, 1919). A review and report of further investigations. It comes out that dilute acids (acetic acid especially) are more active than the concentrated; the maximum is about 20 per cent. in the case of acetic acid. The action of acetic acid in the neighbourhood of its maximum activity on an enamel (also on steel) is subject to various irregularities, which render this acid unsuitable for use in a standard test; a further objection is that acetic acid being a liquid might be supplied of various strengths. It has been found that citric and tartaric acids, which are sold as solids presumably pure, are more active on an enamel at a given concentration than acetic acid is, and so they give a more definite result in a given time; the relative action of citric and tartaric acids at given concentrations appears to be about equal and slight errors in concentration between 10 per cent. and 50 per cent. are of minor importance with regard to difference in activity. Tartaric acid was found to be much more stable than citric acid, but irregularities are slight, and seem to make no material difference on the action of a standard solution of the acid on the enamel.

VII.—COLOURS & DECORATIVE PROCESSES.

NEW POWDER PROCESS WITH U.G. COLOURS.—(*Glas-Ind.*, **29**, 14, 1918). A short note. Hitherto the powder process for U.G. colouring has not been usable, because the biscuit surface allowed in sufficient cleaning of the decorated ware from the excess of U.G. Colour. According to the new process this difficulty will be removed by making the biscuit surface watertight and glossy by a layer of material which leaves no residue (of ash, etc) on firing in the muffle kiln. But the burning of this immediate layer may cause the U.G. colour layer either to rupture or by softening to be washed away. On the cleaned surface of biscuit or glost porcelain, earthenware or fayence is produced an elastic (at first adhesive, later shining dried on) skin, which adheres so firmly that it can be covered with adhesive varnish or U.G. colour prints by pencilling or spraying on the biscuit. After removal of the printing paper, the skin can be thoroughly cleaned with water. If a rubber stamp be used, the washing off with water is not done. The varnish or U.G. prints can be powdered with finely ground U.G. colours on the printed places, and the excess of colour can be easily removed with a large pencil, wadding, etc. Before glazing, the elastic skin and printer's varnish are burned off in the kiln, after which the pieces are dipped and set for glost firing. As elastic skin may be used alcohol-ether solution of collodion camphor which contains a small quantity of castor oil. It can be coloured with colours soluble in spirit, as aniline colours.

METAL COATINGS ON GLASS AND CERAMIC WARES.—(*Glas-Ind.*, **29**, 105, 1918). Cuprous or cupric hydroxide is added to a solution of silver nitrate, and the resulting grey precipitate is dissolved in hydrofluoric acid and applied to the glass or porcelain ware previously roughened by sand blast. In order to secure adherence of the metal, the metal of the solution is converted into the metallic state. This is attained by dusting the surface with a mixture of metal particles, and reducing. Such mixtures are powdered copper or zinc with iron, nickel, cobalt, lead, or bismuth. After reduction the wares are found to be coated with a thin layer of metal, which suffices for electrical conduction and causes the laying on of further

metallic deposits. To make the surfaces still better conducting, they are dried by means of a rotating brush and then quickly rubbed smooth until they show a shining appearance and facilitate the passage of the electric current. In many cases it is only desired to produce electrodeposition of metal on parts of the objects. It is then necessary merely to roughen the places to be decorated. The places to remain smooth are then covered, as a rule with thin celluloid stencils. If the roughening be effected with acid bath, a suitable covering varnish must be provided, which can be produced from 12 parts wax, 7 resin, 3 gum mastic in one melting. The deposit can be wiped off the smooth parts.

Objects thus treated can next be put in as cathodes in suitable electrolytes of gold, silver, or other metals, and connected with the source of electric current, so that a special coating of electrolytically deposited metal is fixed, and it is suitably decorated.

The decoration process can be simplified by using acid for roughening the glass or porcelain. The best results are obtained from a bath consisting of 1000 g. water, 270 potassium fluoride, 150 potassium sulphate and 280 hydrochloric acid.

PRODUCTION OF CERAMIC PICTURES.—(*Glas-Ind.*, **29**, 105, 1918). Relates to transfers on glass, metal or porcelain wares.

SUBSTITUTE FOR FAT OIL IN PORCELAIN PAINTING.—(*Cer.*, **21**, 195, 1918). See abstract of article by Larchevèque, under the heading "Works Executed by Prisoners of War" (Section VIII.).

BROWN GLAZE—(*Brick, Pot. Tr. J.*, **26**, 132, 1918). Note relating to a fusible brown glaze, which melts at cone 4a, but is fired at cone 8. It is suggested that it is a natural clay resembling Klingenberg clay. The composition is given as 58·69 silica, 10·87 alumina, 5·57 ferric oxide, 3·93 lime, 1·92 magnesia, 4·2 potash, 1·83 soda, and 13·23 loss on ignition.

ENAMELLING BRICKS.—(*Brick, Pot. Tr. J.*, **26**, 184, 1918. Includes recipes for stains to give black, blue and green—either glaze enamel or engobe.

PHOSPHATE GLAZES.—(*Brick, Pot. Tr. J.*, **26**, 201, 1918). Relates to glazes prepared by H. Fritz. See TRANS., **18**, Abs. 141, 1919.

SOME PRINCIPLES OF POTTERY DESIGN.—J. Burton (*Pot. Gaz.*, **43**, 395, 1918). Report of address delivered before the Art Section of the Ceramic Society.

COLOUR EFFECTS ON POTTERY.—(*Pot. Gaz.*, **43**, 544, 632, 1918. A general discussion, with special reference to effects obtained by dipping in transparent coloured glazes, and also with the use of opaque white glaze, etc.

ACID TEST ON ENAMELS.—W. D. Collins (*J. Ind. Eng. Chem.*, **14**, 8, 1919). Relates to results of tests made on 61 samples of American enamelled kitchen ware. See abstract in *J. Amer. Cer. Soc.*, **2**, 843, 1919.

METALLIC COATING FOR RUST-PROOFING OF IRON AND STEEL—(*Circular of the Bureau of Standards*, No. 80). The section on pickling and cleaning metals is interesting to enamellers. See abstract in *J. Amer. Cer. Soc.*, **2**, 844, 1919.

MAGNESIA AS AN OPACIFIER.—V. S. Schory (*J. Amer. Cer. Soc.*, **2**, 477, 1919). Relates to high-fire glazes for once fired ware, containing 0·30 MgO, the rest of the fluxing oxides being K_2O and CaO, with some ZnO in several of the glazes. The glazes when fired to form opaque, glossy coats, are really in the condition of overfired porcelains. Zinc and barium increase the transparency of the coats only as they increase the fusibility.

THE CAUSE AND CONTROL OF BLISTERING IN SHEET-STEEL ENAMELLING.—C. Treischel (*J. Amer. Cer. Soc.* **2**, 774, 1919). Relates to the type of blistering evidenced by a splitting apart of the steel sheet—

not separation of the enamel from the iron. It is concluded that hydrogen certainly has much to do with the blistering in sheet-steel enamelling.

In order to make commercial use of the results obtained, it would be necessary to change the strength of the pickling solution to about 3 per cent. The time of pickling would not be very noticeably increased, though it would be necessary to have each piece rubbed with a brush before washing, to remove some of the adhering scale. This change has resulted in there being practically no cases of blistering during 10 months, whereas with the old method losses of 40 per cent. were not uncommon on some lots of stampings.

THE CLEANING OF SHEET STEEL AND IRON FOR ENAMELLING PURPOSES.—R. R. Danielson (*J. Amer. Cer. Soc.*, **2**, 883, 1919). A summary of the methods used in the cleaning and pickling of metals. New methods (borrowed from related industries), such as removal of grease with chemical cleaners and pickling with acid substitutes, have been introduced by some enamellers with very satisfactory results.

VIII.—COSTS, MANAGEMENT, ORGANIZATION, COMMERCIAL REPORTS.

MODERN METHODS OF MEASURING, WEIGHING, COUNTING, AND MIXING BY MACHINERY.—G. F. Zimmer (*Cassier's Eng. M.*, **53**, 159, 1918). A discussion of the operations and the apparatus used for different purposes.

SCIENTIFIC MANAGEMENT.—J. Richardson and others (*Cassier's Eng. M.*, **53**, 76, 102, 186, 251, 400, 1918). A discussion of the first principles of scientific management with reference to the conditions in this country. In the article on p. 251, the practical application of scientific management is discussed, with special reference to the results of five years' experience at one American works. The article on p. 400 is concerned with man power under scientific management.

REMUNERATION AND OUTPUT.—I. Holloway and S. B. Scotland (*Cassier's Eng. M.*, **54**, 21, 1918). A discussion of the various methods of remuneration and their relative advantages and disadvantages, especially as regards effect on output.

INDUSTRIAL ILLUMINATION.—(*Cassier's Eng. M.*, **54**, 71, 1918). A discussion of the principles of illumination, natural and artificial, with special reference to practical welfare, work, and elimination of danger.

WASTE OF HUMAN ENERGY ON FACTORIES.—H. G. P. Castellain (*Cassier's Eng. M.*, **54**, 303, 1918). A discussion of industrial fatigue from a medical point of view, with suggestions regarding courses for factory inspectors and medical men.

FRENCH CERAMICS AND GLASS-MAKING DURING THE WAR.—O. Boudouard (*Cer.*, **21**, 33, 1918). A comprehensive review of services rendered to the national defence during three years of war.

Tables are given showing commercial transactions of 1913. A table is also given correlating temperatures in degrees Centigrade, Seger cones, and French decimal cones. Results obtained by Le Chatelier and others in connection with silica refractories are alluded to, as are also the important characters of various other materials, including fused quartz, electrotechnical porcelain, etc.

WORKS EXECUTED BY PRISONERS OF WAR.—M. Larchevèque (*Cer.*, **21**, 195, 1918). A report relating to work done at a porcelain factory at Berry. The present instalment deals with painting on porcelain. It appeared that balsam of copaiba was used instead of fat oil for diluting the colours. Trials of this showed that for obtaining a colour ready for use, less of it was required than of fat oil, and it was easier to use, the colour dried very firmly on the pieces, and there were several other points of advantage.

For diluting colours for grounds the same mixtures of turpentine and fat oil or of turpentine and balsam of copaiba can be used. Diluting with dextrine has the advantage of being less expensive and easy to realise; a 10 per cent. solution or emulsion is made by triturating the dextrine with cold water, and after allowing to settle pouring off the clear solution. The colours are completely desiccated after grinding finely, and then are afterwards triturated with the dextrine solution.

The properties vary according to the colours; a few are quoted:

Colour	Yellow	Purple	Violet	Rose	Turquoise	Emerald Green
Weight of colour	100	180	180	160	180	180
Weight of Dextrine (10% solution) ..	60	45	50	65	55	45
Percentage (of Solution)	37·5	20	21·75	28·38	23·4	20

After diluting the Colours, it is necessary to sift through a bronze sieve No. 200.

APPRAISAL OR INVENTORY?.—W. F. Worcester (*Brick*, **52**, 512, 1918). An inventory is ordinarily a continuous listing of items, named but not adequately described. An appraisal completely describes every item of the permanent plant, and also classifies, arranges or indexes the items so that they are readily accessible.

Architectural appraisers measure and describe the buildings, kilns, etc. Mechanical appraisers list and describe every item of equipment. Depreciation is estimated as a percentage according to condition, as age has little to do with appreciation, and usually gives too low a valuation.

The article proceeds to describe how appraisal aids insurance adjustment, etc.

REPRESENTING FACTS GRAPHICALLY.—J. K. Moore (*Brick*, **53**, 39, 1918). An illustrated article showing how graphs enable conclusions to be drawn independently. The illustrations apply more particularly to the clay working industry. The subjects which can be treated graphically include organization, factory diagram showing distances materials or articles must be moved from receipt of raw material to packing of the finished product, yard layout showing relative position of stock to kilns and packing place, and control diagrams. The control diagrams include monthly analyses of sales, costs and manufacturing costs, sales records, monthly output, firing curve for control of kilns, monthly percentage of best ware, monthly drying losses and kiln losses, etc.

CLAY PRODUCTS IN INDIA.—(*Brick*, **53**, 201, 1918). A description, with four illustrations of the works established in 1892 by Messrs. Burn & Co., Ltd., at Jubbulpore (Central Provinces); they have another works at Raneegunge, Bengal. The Jubbulpore works make glazed stoneware and drain pipes, and also fireclay bricks, crucibles, retorts, glass pots, etc. The drain pipes compete in Bombay with British pipes. There are 32 round down-draught kilns and some muffle kilns, all coal fired at present. A recording pyrometer is used and gives little trouble, but proves very valuable for controlling the firing.

SITE INVESTIGATION.—J. K. Moore (*Brick*, **53**, 457, 545, 1918). An article explaining the necessity of thorough investigation of site for successful development of works. Reference is made to land survey, drilling and

clay testing, topographical maps and their uses, diamond drills, and tests of samples.

PORCELAIN INDUSTRY IN FRANCE BEFORE THE WAR.—M. Larchevèque (*Cer.*, **21**, 17, 49, 101, 135, 153, 157, 1918). A comparative study of the French industry, and the German and Austrian statistics are given as to the number of works and workpeople, etc.

The researches of G. Vogt are briefly enumerated, and allusion is made to those of Lavezard, Giraud, A. Granger, Le Chatelier, Damour, Coupean, and Chantepie, Wologdine, Boudouard, De Luynes, Verneuil, Leduc, Robineau, Ganter, and others in France, and of Heraeus at Hanau, Bidtel at Meissen, Geitner at Schneeburg, Gunzel at Haïda, in addition to Seger, Aron, Cramer, Rosler, C. Bischof, Schumacher, Hecht, Turrschmiedt, Kosman, P. Rohland, Schulze, Schöne, Jothum, Olschewsky, Otto, etc.

The technical and art schools are also referred to.

The localities in France, Germany, and Austria for various raw materials (kaolins, clays, felspars and pegmatites, sands, quartz, etc.) are given; and the general methods of preparing bodies, glazes, etc., also various methods of shaping (including the use of metal moulds for dry bodies), and glazing. The fuel (chiefly wood or coal), ovens, etc., are briefly reviewed, and colour and other decoration (including liquid colours). These liquid colours are syrupy solutions containing glycerine, which is mixed with easily decomposable metallic salts such as nitrates and acetates. Very regular clear tints are given by chromium, cobalt, and nickel colours (in small quantity), and light to dark tints by uranium, gold, and platinum. These colours were only an improvement on Brongniart's process for preparing rose Isabelle. Coloured glazes are also referred to briefly, as well as gold and lustres and other decorations, including chromos, reliefs, incrustations, and colours by vaporisation.

Economic aspects of the industry are also discussed, and there is a brief technical review of the National factory at Sèvres.

REPORT ON THE MANUFACTURE OF SILICA BRICKS, ETC.—(*Quarry*, **23**, 21, 1918). Relates to phthisis in a silica brick maker, through inhalation of dust, as recorded in a Home Office report.

THE DEPRECIATION OF KILNS.—(*Brick, Pot. Tr. J.*, **26**, 182, 1918). A brief discussion of the allowance for depreciation, with suggested percentages for several types.

ENCOURAGEMENT OF ART IN THE POTTERIES.—A. E. Gray (*Pot. Gaz.*, **43**, 133, 1918). See TRANS., **17**, 159, 1918.

SCIENCE AND THE PRACTICAL MAN.—C. Johns (*Pot. Gaz.*, **43**, 465, 1918). Popular lecture at Sheffield. See also TRANS., **17**, 372, 1918.

SCIENCE AND LOCAL INDUSTRIES.—C. Johns (*Pot. Gaz.*, **43**, 941, 1918). A lecture delivered at Swansea, with special reference to the activities of the locality. See also TRANS., **18**, 1, 1919.

SIMPLIFIED ACCOUNTING FOR BRICK MANUFACTURERS.—G. S. Olive (*Claywr.*, **69**, 286, 1918). Practical suggestions for keeping accounts.

THE BONUS SYSTEM.—(*Claywr.*, **70**, 132, 1918). An account of the application of the bonus system (of paying wages) to brickworks. It resulted in greatly increased production, though the cost per ton remained practically the same.

THE REWARD SYSTEM OF PAYING WAGES.—(*Cassier's Eng. M.*, **53**, 53, 1918). Relates to a system based on the principle of paying the worker a reward for efficiency in addition to wages. The system is fully described by H. Atkinson in "A Rational Wage Systems," London, 1917, 1s. 6d. net.).

BONUS PLAN FOR POWER PLANTS.—(*Cassier's Eng. M.*, **53**, 139, 1918). Relates to a scheme in which graphic charts are used in the boiler room and in the engine room.

EFFECT OF BONUS ON OUTPUT.—(*Cassier's Eng. M.*, **53**, 212, 1918). Relates to experience of the Ministry of Munitions.

POWER PLANT ACCOUNTING.—W. A. Tatler (*Cassier's Eng. M.*, **53**, 37, 1918). A discussion of the form in which accounts should be kept, in order that a guide may be supplied for taking steps to improve continually the efficiency of the plant.

EXPENSES AND COSTS.—(*Cassier's Eng. M.*, **53**, 301, 1918). Paper by H. L. Gantt, with special reference to overhead expense or "burden," and to standardisation of methods.

TIME STUDY.—(*Cassier's Eng. M.*, **53**, 170, 1918). A discussion of the elementary principles of time study as the basis for a scientific system of paying wages. On p. 155 is an editorial article on "Time Study in Factories."

HOURS OF LABOUR AND FATIGUE ELIMINATION.—J. Holloway, and S. B. Scotland (*Cassier's, Eng. M.*, **53**, 391, 1918). A discussion—based on practical experience—of the best means of securing sustained high production.

FUTURE PROBLEMS OF THE GERMAN CERAMIC INDUSTRY.—M. Roesler (*Glas-Ind.*, **29**, 177, 185, 1918). See abstract under same title from *Ker. Rund.* (**26**, 164, 1918).

DESIGNING OF FACTORY LAYOUTS FOR THE CLAY INDUSTRIES.—T. W. Garve (*J. Amer. Cer. Soc.*, **2**, 195, 1919). Effectiveness, simplicity, and ornateness are fundamentals for the factory designer, and their importance is in the order given. The engineer's work—of designing the frame after the plan has been worked out—is of chief importance in designing factories. The architect and artist are not essential. Special reference is made to clay haulage, clay storage, machinery building, power house, kilns, building brick plant, terra cotta plant, and silica brick plant.

POTTERY IN VOLHYNIA.—Neumann (*Tonind. Ztg.*, **42**, 287, 1918). A short general account, with an illustration of a village potter at work, together with a ground plan and vertical section of the kiln.

WHITE RUTHENIAN VILLAGE POTTERY.—(*Tonind Ztg.*, **42**, 399, 1918). Based on an article by Captain Prof. F. Curschmann. There are two illustrations, one showing an old potter at work, and the other a few specimens of ware.

THE BUNZLAU CLAY INDUSTRY.—Busse (*Tonind. Ztg.*, **42**, 683, 1918). A short general review.

TURKISH POTTERY.—(*Tonwar. Ofen. Ztg.*, **42**, 356, 1918). A short note.

X.—GLASS.

DURABILITY OF LEAD POTASH GLASS.—Cauwood, Turner, and Webb (*Pot. Gaz.*, **43**, 121, 1918). From *J. Soc. Glass Tech.* See also TRANS., **17**, Abs., 165, 1918.

ANNEALING OF GLASS.—S. English and W. E. S. Turner (*Pot. Gaz.*, **43**, 121, 1918). Paper read at meeting of Society of Glass Technology.

AMERICAN PRACTICE IN THE GLASS INDUSTRY.—H. H. Pitt (*Pot. Gaz.*, **43**, 207, 1918). See also TRANS., **17**, Abs., 165, 1918.

POTASH FOR GLASS-MAKING.—P. G. H. Boswell (*Pot. Gaz.*, **43**, 224, 1918). Paper read at February Meeting of Society of Glass Technology.

POT FAILURE.—S. N. Jenkinson (*Pot. Gaz.*, **43**, 315, 1918). A discussion of some causes. See also TRANS., **17**, Abs., 165, 1918).

SCIENTIFIC GLASSWARE.—M. W. Travers (*Pot. Gaz.*, **43**, 631, 1918). Abstract of paper read at the Annual Meeting of Society of Chemical Industry. It referred mainly to the course of development of the manufacture of scientific glassware.

THE ART OF COLOURING GLASS.—H. Rosenthal (*Pot. Gaz.*, **43**, 635, 1918). Reprinted from *J. Ind. Eng. Chem.*, being report of paper read at Meeting of New York Section of the American Chemical Society.

TECHNICAL CONTROL OF A WINDOW-GLASS TANK FURNACE.—C. J. Brockbank (*Pot. Gaz.*, **43**, 810, 1918). Reprinted from TRANS., *Amer. Cer. Soc.*, Vol. **17**.

CHOICE OF REFRACTORY MATERIALS FOR USE IN THE GLASS INDUSTRY.—(*Trans. Faraday Soc.*, **13**, 190, 1918). Report of a joint Meeting of the Society of Glass Technology and the Faraday Society. The full papers appear in *J. Soc. Glass Tech.*, **1**, 109, 1917.

PRODUCER FIRED GLASS TANK FURNACES.—(*Chemical Trade J.*, **62**, 285, 1918). Report of paper read before Society of Glass Technology by A. B. Roxburgh.

THE TECHNIQUE OF OPTICAL GLASS MELTING.—C. N. Fenner (*J. Amer. Cer. Soc.*, **2**, 102, 1919). After a brief reference to the circumstances which led to co-operation of the Geophysical Laboratory and American manufacturers of optical glass, and a summary account of preliminary operations, the author proceeds to describe and discuss the use of cullet, setting the pot and filling in the batch, melting and fining, bubbles and their origin, the function of arsenic, leakage, skimming and stirring, and batch compositions for various types of glass, with some concluding remarks. There are a few illustrations, mostly plotted curves.

AN IMPROVED METHOD OF OPTICAL GLASS MANUFACTURE.—G. W. Morey (*J. Amer. Cer. Soc.*, **2**, 146, 1919). A paper supplementary to the previous one by Fenner. It has special reference to a new schedule devised by the author, constituting the "24-hour" process, by which the production of optical glass is practically doubled.

DEVITRIFICATION OF GLASS.—N. L. Bowen (*J. Amer. Cer. Soc.*, **2**, 261, 1919). A general discussion of the subject, with discussion also of particular cases, especially in connection with optical glass.

IMPROVED GOLD RUBY GLASS.—H. T. Bellamy (*J. Amer. Cer. Soc.*, **2**, 313, 1919). The behaviour of colloidal gold in the solid solution (gold ruby glass) appears to be similar to its behaviour in aqueous solutions (in both cases existing as colourless, green, red, blue, violet, or brown particles). When ruby glass is at the melting temperature the particles are colourless, and when suddenly chilled they remain colourless, but if the glass is reheated to the softening point, the particles become ruby. Further heating tends to produce other colours. It is concluded from results of trials that the range of stable red glasses is rather wide, from a light red opalescent to a very dark red glass. The quantity of gold used to produce these shades of red varied from one part in ten thousand to one part in three thousand. The use of sufficient tin oxide to stabilize the gold and produce a ruby colour with the minimum quantity of gold is new and has been patented. A stable, reliable, gold ruby glass can be economically produced, and the presence of other colours is not a natural phenomenon of gold ruby glass, for when the necessary components are properly proportioned, the gold particles are either red or colourless.

CHEMISTRY IN THE LITERATURE OF GLASS.—L. Springer (*Glas-Ind.*, **29**, 113, 121, 129, 137, 1918). A general survey, the successive sections or chapters treating of "Chemical Signs and Formulae," "Raw Materials," "Colouring, Decolouring, and Refining Materials," "Chemical Processes—Glass Batches," etc.

COLOUR DECORATION OF GLASS.—O. Parkert (*Glas-Ind.*, **29**, 153, 1918). A short note relating to modern "Eglomisétechnik." The ordinary black bottom colour most frequently used consists of 88 parts asphalt, 12 sandarac, and 26 alcohol. For covering grounds of other colours, the suitable colouring material is introduced into a colourless varnish consisting of 65 parts resin, 25 parts gelatine dissolved in alcohol, and 30 parts alcohol; mineral colours are added to give certain tints.

GLASS-LIKE PORCELAIN.—(*Glas-Ind.*, **29**, 154, 1918). A short note relating to Rosenthal porcelain.

MANUFACTURE OF MIRRORS.—P. M. (*Glas-Ind.*, **29**, 161, 1918). A short account of the process.

GLASS DISHES SUBSTITUTED FOR PLATINUM.—(*Glas-Ind.*, **29**, 169, 1918). A short note referring to article by Gewecke in *Chemiker-Zeitung* for 1917, p. 297. It relates to the substitution of the ordinary platinum basins used as cathodes by glass vessels silvered inside.

GLASS SUBSTITUTE IN FRANCE.—(*Glas-Ind.*, **29**, 195, 1918). A note referring to such products as "Siloxide," artificial mica, cellulose products like "Collosan," "Cellite" (cellulose acetate), etc.

VOLATILIZATION OF IRON FROM OPTICAL GLASS POTS BY CHLORINE AT HIGH TEMPERATURES.—J. C. Hostetter, H. S. Roberts and J. B. Ferguson (*J. Amer. Cer. Soc.*, **2**, 356, 1919). An illustrated account of an investigation carried out by the authors, first on a laboratory scale and afterwards on a large scale. The results demonstrate that iron can be volatilized from glass pots under factory conditions, and that there is nothing difficult or impracticable in carrying out the process. It is also shown that the amount of iron in the pot could be readily reduced by half. The removal of iron from the pots seems to have made them more porous, and hence more readily attacked by the melted batch, though the porosity might perhaps not have been too great under a different burning schedule. The authors are confident that with proper heat treatment difficulties of this kind could easily be overcome. The process could apparently be applied to grog or other pot material.

OPTICAL GLASS MANUFACTURE.—C. N. Fenner (*J. Amer. Cer. Soc.*, **2**, 373, 1919). A discussion of paper by G. W. Morey in same journal, p. 146, with special reference to the possibility of milkiness or opalescence in some glasses.

MANUFACTURE OF OPTICAL GLASS.—W. S. Williams and C. C. Rand (*J. Amer. Cer. Soc.*, **2**, 422, 1919). "The present paper is intended as a brief statement of the general problem of making optical glass." The chief topics dealt with are requirements for optical glass, raw materials, pots, stirring, moulding and annealing, and chemical composition (of different types). The chemical composition, refractive indices, etc., are given in a number of tables.

COOLING OF OPTICAL GLASS MELTS.—H. S. Roberts (*J. Amer. Cer. Soc.*, **2**, 543, 1919). Relates to glass left to cool in the pot after removal from the melting furnace. The conditions to be sought are that the cooled melt shall break into large, reasonably rectangular blocks, having smooth faces, and that not much glass shall be spoiled by want of homogeneity (striæ, bubbles, crystals or devitrification). The whole range of cooling is divided into the stage of fluidity, the annealing range, and the final stage. These stages are discussed with the aid of illustrations.

DEVITRIFICATION OF GLASS.—(*J. Amer. Cer. Soc.*, **2**, 576, 1919). A discussion of N. L. Bowen's article under that title (p. 261 of same J.).

GLASS ETCHING.—R. Hohlbaum (*Glas-Ind.*, **29**, 9, 17, 25, 1918). Extracted from the author's book on hollow glassware, and relates to matt-etching, production of bright pattern on matt ground, production of engraving, production of prints, deep etching, production of relief decoration on flashed glass, etc., The title of the book is: Zeitgemasse Herstellung, Bearbeitung und Verzierung des feineren Hohlglases, von Rudolf Hohlbaum.

IRIDESCENT GLASS.—(*Glas-Ind.*, **29**, 41, 1918). Another extract from Hohlbaum's book referred to in the foregoing abstract. Several recipes are included.

GLASS DECORATION.—(*Glas-Ind.*, **29**, 41, 1918). A short note relating mainly to enamel decoration.

GLASS DECORATION.—(*Glas-Ind.*, **29**, 57, 1918). Relates to production of labels in several colours, etc.

LOW AND BROAD, OR HIGH AND NARROW, GLASS POTS?.—(*Glas-Ind.*, **29**, 65, 1918). The views of three experts are presented.

TRANSPARENT AND SEMI-TRANSPARENT GLASSES.—(*Glas-Ind.*, **29**, 81, 1918). Recipes for alabaster glass, bottle glass, pressed glass, plate glass; also green glass from such materials as lava, basalt, trachyte, phonolite, with or without felspar.

MANUFACTURING COSTS IN THE GLASS INDUSTRY.—J. D. Mills (*J. Soc. Glass Tech.*, **3**, 14, 1919). A discussion of the uses of a costing system, the elements of cost, cost of glass making, furnace charges, labour charges, oncosts or overhead charges.

A COSTING SYSTEM FOR A GLASS BOTTLE FACTORY.—F. Sweeting (*J. Soc. Glass Tech.*, **3**, 27, 1919). A contribution to the discussion on the preceding paper (by J. D. Mills).

SOME GERMAN GLASSWORKS IN MARCH AND APRIL, 1919.—S. N. Jenkinson (*J. Soc. Glass Tech.*, **3**, 144, 1919). A brief review of the conditions found during a visit.

SOME RECENT IMPROVEMENTS IN THE DESIGNS OF GLASS-WORKS FURNACES AND GAS-PRODUCERS.—J. S. Atkinson (*J. Soc. Glass Tech.*, **3**, 148, 1919). An illustrated discussion of various questions, including the design of gas producers and the Stein recuperative furnace. On the basis of figures given, it was claimed that the Stein pot furnace and the Stein tank furnace (though the latter presented no novel features apart from the special system of recuperators) had an exceedingly low consumption of coal compared with other good types of furnace.

THE GLASS INDUSTRY OF NORTH AMERICA.—W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 166, 1919). A comprehensive account based on notes taken during an extensive tour of inspection. The sections treat of the location of the industry, the raw materials, mixing of batch, glass melting furnaces, annealing processes, pyrometric control, manufacture of bottles and jars (by hand and by machinery of various types), manufacture of electric light bulbs, glass tubing and rod, chemical and scientific glass-ware, optical glass, refractory materials, general labour conditions, etc. As an appendix appears a table which attempts to correlate the output of glass with the consumption of fuel when a gas pressure regulator was in use.

THE ANNEALING TEMPERATURES OF LIME SODA GLASSES.—S. English and W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 125, 1919). From practical experience it appears that lead glasses are readily annealed, but chemical glassware requires a high annealing temperature followed by slow rate of cooling, to first remove strain and then prevent its recurrence. The present paper relates mainly to the upper annealing temperature for the types of glass under consideration, the compositions of which are given

in percentages. In 13 glasses examined the soda ranged from 25·34 to 11·22 per cent. and the lime from 0·21 to 18·17 per cent., the silica being from 73·18 to 74·99 per cent. with two exceptions (66·71 and 69·73 respectively).

The results show that glasses with a high proportion of alkali can be annealed at a fairly low temperature, though higher than for lead glasses, and that they soften comparatively readily like lead glasses. As alkali decreases and lime increases the annealing temperature rises. High lime content is not uncommon in glass for common bottles, especially by hand processes. Ordinary white flint (lime-soda) glass for medicine bottles and for paste, sauce, and pomade bottles, etc., usually have between 17·2 and 14·9 per cent. soda, and between 7·5 and 9·4 of lime.

The different soda-lime glasses therefore cannot be treated alike in the lehr, and any alteration of batch composition must be associated with a corresponding change in the heat applied to bring about effective annealing, as an alteration of 5° from the appropriate annealing temperature has very great influence on the speed of annealing.

FURTHER INVESTIGATIONS ON CHEMICAL GLASSWARE.—C. M. M. Muirhead and W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 129, 1919). Relates to tests made on an American zinc borosilicate glass as regards action of water, caustic soda, sodium carbonate, and hydrochloric acid. The results were good all round.

GLASS RESEARCH IN THE YEAR ENDING MARCH, 1919.—W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 132, 1919). Relates to the year's progress in glass research under the auspices of the Glass Research Delegacy, and includes the third annual report of the Delegacy for Glass Research.

PRELIMINARY FIRING OF TANK FURNACES.—E. E. Fisher (*J. Soc. Glass Tech.*, **3**, 147, 1919). A note by an American glass manufacturer, strongly advocating the practice of heating the furnace up to the highest possible temperature before charging even with cullet. It is claimed that with this method of working, the tanks are much more durable.

EXPLOITATION OF GLASS SANDS IN THE UNITED STATES.—P. G. H. Boswell (*J. Soc. Glass Tech.*, **3**, 72, 1919). An illustrated account.

MANUFACTURE OF GLASSHOUSE POTS.—B. J. Allen (*J. Soc. Glass Tech.*, **3**, 78, 1919). An illustrated description, including the preparation of raw materials. The processes of manufacture referred to comprise the casting of pots by the statical process, the vacuum casting process, and the casting of a covered pot.

SOME PHENOMENA OF POT-ATTACK.—W. Rosenhain (*J. Soc. Glass Tech.*, **3**, 93, 1919). An illustrated account of investigations made at the National Physical Laboratory, including examination by means of X-rays, with suggestions for practical applications.

NOTES ON POT ATTACK.—E. A. Coad-Pryor (*J. Soc. Glass Tech.*, **2**, 285, 1918). The bottom of a pot was invariably found to be attacked more than the sides, and a rod of refractory material suspended in the centre of the melted glass was always found to become tapered, with the thin end downwards. The pots and rods had been fired at uniform temperatures, so there was no question of local formation of sillimanite to exert a protective action. With rods and pots of denser material it was found that where the pot material had a density higher than that of the glass, a taper of the rod was produced in the opposite direction. This phenomenon is common to all materials in the process of solution. Progress has been made which it is hoped may lead to the production of pots commercially, by a slip casting process, lined with a layer of refractory material highly resistant to the attack of molten glass.

DISCUSSION OF PAPERS ON GLASS POTS.—(*J. Soc. Glass Tech.*, **2**, 288, 1918). Remarks on preceding papers, by M. W. Travers, S. N. Jenkinson, W. J. Rees, J. Connolly, and A. B. Searle.

PROVISIONAL SPECIFICATIONS FOR GLASS REFRACTORIES.—(*J. Soc. Glass Tech.*, **3**, 3, 1919). See also TRANS., **18**, 420, 1919.

BOTTLE GLASS AND GLASS-BOTTLE MANUFACTURE.—W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 37, 1919). A review of important factors connected with the manufacture including durability and production, factors governing production, etc. Compositions are given for syphon bottles and other white glass for bottles.

OPTICAL GLASS IN RELATION TO WEATHERING PROPERTIES.—A. V. Elsden, O. Roberts, and H. S. Jones (*J. Soc. Glass Tech.*, **3**, 52, 1919). Has reference to two types of film or deposit occurring on the surface of the glass portions of optical instruments of war, and of tests applicable to them, including the dimming test.

SOME EXPERIMENTS WITH A GAS-FIRED POT FURNACE.—M. W. Travers (*J. Soc. Glass Tech.*, **3**, 70, 1919). An illustrated account of experiments the results of which may find application in the design of furnaces, for special purposes. A modification was introduced which practically eliminated the cracking of the fronts of pots, previously a source of much trouble.

EFFECT OF CONTINUED ACTION ON CHEMICAL GLASSWARE OF WATER, ACID, AND ALKALI.—J. D. Cauwood and W. E. S. Turner (*J. Soc. Glass Tech.*, **2**, 235, 1918). Relates to the results of repeated action of boiling water, hydrochloric acid, caustic soda, and sodium carbonate respectively on representative flasks of the three types of glass made for chemical ware (zinc-aluminium borosilicate, aluminium borosilicate, and soda-lime glasses).

On the whole, the soda-lime glasses seem to obtain a more resistant surface by continued treatment with either water or hydrochloric acid. The surfaces of the boro-silicate glasses are not improved by hydrochloric acid, but are somewhat improved by successive treatment with water. None of the glasses is improved by the continued action of alkali (either caustic or carbonated).

SOME INCIDENTAL NOTES OF A FLINT-GLASS WORKS MANAGER.—H. J. Powell (*J. Soc. Glass Tech.*, **2**, 241, 1918). A series of notes relating to experiments, tests, and miscellaneous incidents between 1875 and 1916.

EFFECT OF TEMPERATURE ON THE RATE OF CORROSION OF GLASS.—J. D. Cauwood and W. E. S. Turner (*J. Soc. Glass Tech.*, **2**, 260, 1918). Relates to effects of water, hydrochloric acid, and sodium carbonate.

REFRACTORY MATERIALS AND THE GLASS INDUSTRY.—J. W. Cobb (*J. Soc. Glass Tech.*, **2**, 262, 1918). A discussion of certain aspects of the subject, including refractoriness and composition, refractoriness and grain size, shrinkage on firing, action of fluxes and alkaline vapours, joints and cements, and thermal conductivity.

THE REQUIREMENTS OF CLAY FOR GLASSHOUSE POTS.—S. N. Jenkinson (*J. Soc. Glass Tech.*, **2**, 272, 1918). Relates largely to the proposed provisional specification, and suggestions for standards, with brief comments on the several materials. The author strongly emphasizes the advisability of the pot material being vitrified before use, even though some loss of refractoriness were involved.

SOLUBILITY OF CLAY IN GLASS.—J. H. Davidson and W. E. S. Turner (*J. Soc. Glass Tech.*, **2**, 280, 1918). Relates to the solubility of clay previously fired at different temperatures. Fired clay is always readily soluble in a soft glass batch when crushed fairly finely, the rate of solution depending on the size of the particles (that is on the surface exposed). Attack is therefore diminished by reducing the surface, as by firing the pots to the vitrification temperature, and by making dense pots with a smooth surface. The

making of such dense pots is apparently most readily accomplished by the casting process.

NOTE ON THE FIRING OF GLASS POTS.—M. W. Travers (*J. Soc. Glass Tech.*, **2**, 170, 1918). Relates mainly to the treatment and behaviour of pots at and after the time they are placed in the pot arch. During the first portion of this period the clay still contains absorbed water, and the binding material also contains water combined in the form of hydrated silicates. This water is completely expelled at dull red heat. In the second period the grog and binding clay are still clearly defined, and this condition usually continues until the pot is set in the furnace. In the third period the body of the pot becomes apparently homogeneous, the change taking place only very slowly below 1300°C., and very rapidly at 1350°C., and higher temperatures. In the second period the pot would be very readily attacked by molten glass, and the rapidity of the attack increases rapidly with rise of temperature. The vitrified pot (in the third period) is not attacked by molten glass even when the pot begins to soften by heat. The author proceeds to describe how some of the pot troubles have been eliminated. A supplementary reference to specimens, etc., appears on p. 270.

ADDITIONAL NOTES ON POT FAILURE.—S. N. Jenkinson and P. Marson (*J. Soc. Glass Tech.*, **2**, 175, 1918). The authors conclude that pots may crack at the bottom owing to insufficient preliminary burning in the pot arch, and that bricks placed under the pot distort the bottom. They also believe that a down-draught arch and a high temperature should prevent this form of cracking, and that a down-draught furnace should also assist in preventing cracking, as the siege will be hotter.

RESISTANT PROPERTIES OF SOME TYPES OF FOREIGN CHEMICAL GLASSWARE.—J. D. Cauwood and W. E. S. Turner (*J. Soc. Glass Tech.*, **2**, 219, 1918). A report on tests and discussion of results. The following points are brought out clearly: The tendency among chemical glass manufacturers now is to rely mainly on the zinc-aluminium boro-silicates or the aluminium boro-silicates, though for reasons not obvious the former seem to be preferred. The lime-soda glasses, though not usually very resistant to water, behave well towards strong caustic alkali, only moderately well towards dilute caustic alkali, and break down very badly towards sodium carbonate; towards acid they are generally the best glasses available. Silica promotes resistance towards water and acid, but not to caustic or carbonated alkali. Boric oxide increases the resistance of glass towards water though beyond about 12 molecules per 100 molecules of silica this effect probably diminishes. Boric oxide weakens the resistance of a glass towards alkali and hydrochloric acid. Lime is not generally to be recommended as an important component of water-resisting glass, and where sodium carbonate is to be used, glass containing lime should be avoided. Lime in glass seems to produce resistance to strong caustic alkali and hydrochloric acid. Glasses containing large proportions of the alkalies cannot withstand water, acid, or alkali.

REVIEW OF THE BRITISH GLASS INDUSTRY.—W. F. J. Wood (*J. Soc. Glass Tech.*, **2**, 72, 1918). The Presidential Address, delivered April 17, 1918.

A COKE PRODUCER GAS FIRED GLASS TANK FOR THE PRODUCTION OF WHITE GLASS.—A. B. Roxburgh (*J. Soc. Glass Tech.*, **2**, 82, 1918). A descriptive account, without illustrations.

ANNEALING OF GLASS.—S. English and W. E. S. Turner (*J. Soc. Glass Tech.*, **2**, 90, 1918). Glass manufacturers are mainly interested in the study of strain in glass in order to avoid its occurrence, for which purpose it is essential to know at least:—(1) The temperature at which strain can be removed rapidly without causing the glass to undergo deformation. (2) The lowest temperature at which for all practical purposes the strain can be removed. (3) The quickest rate of cooling between these two temperatures

at which the glass can safely be cooled without the recurrence of strain. Thus there are two temperatures of importance in the annealing of glass, and these temperatures (upper and lower) can be considered as the critical annealing temperatures of glass. The critical annealing temperatures can be determined by an optical method and a mechanical method, which are described, with illustrations.

Just below the annealing temperature glass may be cooled fairly rapidly, but as the glass stiffens the rate of cooling must be lowered and remain very slow until the glass has become rigid. It was found possible to cool a glass having an upper annealing temperature of 585—590° at the rate of 25° per hour between 590° and 500°, but even when the rate was reduced to 9° per hour between 500° and 400° a very slight strain was produced. Below the lower critical cooling temperature the rate of cooling may be raised again.

Glasses of different chemical composition were studied as regards annealing temperature—lead glasses, lime-alkali glasses, boric oxide heat-resisting glass for lamps, and chemical glass ware.

THE GLASS INDUSTRY AFTER THE WAR.—(*J. Soc. Glass Tech.*, **2**, 102, 1918). A general discussion, commenced in London, and continued later at Sheffield.

SOME NOTES ON POT FAILURE.—H. J. Powell (*J. Soc. Glass Tech.*, **2**, 153, 1918). A short discussion on Mr. S. N. Jenkinson's paper under this title.

ANNEALING OF GLASS.—S. N. Jenkinson (*J. Soc. Glass Tech.*, **2**, 154, 1918). A short discussion on the paper by Mr. English and Dr. Turner.

PRODUCTION OF SELENIUM RED GLASS.—F. A. Kirkpatrick and G. G. Roberts (*J. Amer. Cer. Soc.*, **2**, 895, 1919). Selenium has certain advantages over copper and gold as a colouring agent. It is a cheaper colouring agent than gold. With proper manipulation selenium always gives the desired colour while copper-red glass frequently comes from the pot spangled and spotted (owing to different degrees of reduction of the copper compounds). Selenium produces a very pure red, but the red colours from other colouring agents let light pass in other parts of the spectrum.

Trials were made with a soft-working zinc-alkali glass and a plate glass, the formulae and batch weights of which are given, including 0·81 and 0·65 per cent. of selenium respectively. Selenium melts at 217° and boils at 675°C., forming a reddish-yellow vapour. It escapes readily from the batch during the melting and fining periods, and the pot door should be covered with enough wet clay to prevent the escape of the colouring agent. After the selenium becomes incorporated with the glass, probably in colloidal suspension, it is retained permanently, provided the temperature is not raised above 1400°C.

Good red colours were produced in the zinc-alkali glass by the use 0·8 per cent. each of borax, cadmium sulphide, and selenium, and in the plate glass by the use of 0·65 per cent. of selenium, and 0·85 per cent. of cadmium sulphide. The two most essential steps in the process are: first, the door of the pot must be securely closed during the filling and fining periods to prevent escape of selenium vapour; second, the glass must be allowed to cool long enough immediately after gathering (usually half a minute to a minute).

The composition of such glasses had been known for a considerable time, but success in making the glass was attained only by complete practical experiments in which were carried out all the processes of manufacture from compounding the batch mixture to the final annealing of the ware.

SILICA ROCK AND SAND FOR GLASS MAKING.—F. Gelstharp (*Rock Products*, 29, No. 22, Oct., 1919). A general survey, including a few chemical and mechanical analyses. See abstract in *J. Amer. Cer. Soc.*, **2**, 916, 1919.

INFLUENCE OF TEMPERATURE ON THE TRANSMISSION-FACTOR OF COLOURED GLASSES.—M. Luckiesh (*J. Amer. Cer. Soc.*, **2**, 743,

1919). Report of an investigation of ten glasses, including two red and one blue-green coloured by copper, two by cobalt, one by gold, one by manganese, one by chromiun, and two commercial yellow glasses. The author hopes to carry the investigation further.

SOME ASPECTS OF SCIENTIFIC RESEARCH IN RELATION TO THE GLASS INDUSTRY.—E. W. Washburn (*J. Amer. Cer. Soc.*, **2**, 855, 1919). A review of recent developments, with special reference to the American glass industry, which was essentially founded on scientific research and was developed by men trained in the principles of modern chemistry and physics and having the necessary laboratory facilities at their disposal. The glass industry knows *how* to do many things, but *why* is known in few cases.

Special emphasis is laid on the importance of *fundamental research*, the primary purpose of which is to find out the why of some stage of the operation, or to secure quantitative scientific data concerning the materials used, the processes occurring, and the product obtained, both in its completed stage and in different stages of its manufacture.

It is known that the relation between the viscosity of the "metal" and its temperature and composition is one of the important elements associated with the operations of stirring, gathering, drawing, and blowing, yet no measurements of the viscosity of industrial glasses are available in the literature. A little work in this direction has recently been done at the University of Illinois. Similarly, though in a general way the mathematical theory of the process of fining is known, and it is known to be closely connected with the viscosity, with the surface tension, and with the vapour pressure of the molten glass, no measurements of surface tension of industrial glass seem to have been made, nor are any data available concerning the vapour pressures of glasses at different temperatures or concerning the composition of the vapour. Even the density of molten industrial glasses does not seem to have been determined. The reactions which take place in the melt, the compounds formed, particularly those that crystallize out and the conditions under which they crystallize out, are still very little known. The cause of the increased colour of optical glass in which soda replaces potash is not understood. Almost nothing is known of the gases dissolved even in finished glass.

The author has seen a large Mazda lamp bulb destroyed in less than an hour owing to electrolysis occurring between the two leading wires, the layer of bubbles formed along one wire destroying the vacuum.

Some purely scientific questions relating to coloured glass are alluded to.

THE RAPID ELECTROMETRIC DETERMINATION OF IRON IN SOME OPTICAL GLASSES.—J. B. Ferguson and J. C. Hostetter (*J. Amer. Cer. Soc.*, **2**, 608, 1919). Relates to the results of first reducing the iron in acid solution by stannous chloride and then titrating with potassium dichromate, plotting the electromotive force against the volume of the oxidizer instead of using the inaccurate outside indicator. The curve so obtained undergoes two inflections, the first upon the complete oxidation of the excess stannous chloride and the second when the iron has similarly become all oxidized; from the location of these inflections the amount of the dichromate used up in the oxidation of the iron may readily be found.

The electrometric method enables rapid and accurate analyses to be made for both ferric and ferrous iron provided interfering substances are absent. Under favourable conditions such an analysis can be made in ten minutes and may be carried out in glassware.

CASTING PLANT FOR THE MANUFACTURE OF GLASS POTS.—F. H. Riddle (*J. Amer. Cer. Soc.*, **2**, 647, 1919). An illustrated account of the methods used at the Clay Products Section of the Bureau of Standards, and of proposed plans for a plant suitable for casting ten 600-pound glass pots per day. The process can be adapted to many products besides glass pots, and its use is worthy of consideration.

One of the pots has been in use with lime-soda glass for 16 weeks, and was charged 96 times.

CASTING PORCELAIN GLASS POTS.—J. W. Wright and D. H. Fuller (*J. Amer. Cer. Soc.*, **2**, 659, 1919). A note relating to several points of practical importance.

The water content must be low, usually 22-25 per cent. of the dry weight of the materials, the specific gravity of the slip from 1·90 to 1·95, and the viscosity quite high. The body thus produced must have low drying shrinkage and high mechanical strength. The amount of electrolyte varies from 0·20 to 0·33 per cent. of the weight of the dry materials, and the best ratio of sodium silicate to the carbonate is 4:3. An increase in sodium silicate decreases the water content, lowers the viscosity, and shortens the time of casting. An excess of it produces flow or laminated structure.

Kaolins respond most readily to the action of the alkalies, and fireclays least. In slips the use of a more plastic clay in place of a leaner one (fireclay) brings about higher specific gravity, shortening of the time of casting, decreased drying shrinkage, and increased strength. The use of several plastic clays is recommended, and the introduction of a small amount of barium carbonate seems desirable.

GLASS-BLOWING MOULDS.—L. N. Bruner (*Pat. J.*, No. 1564, 1919). Pat. No. 120,416, Nov. 2, 1917. Relates to means for opening and closing the blowing moulds of blowing-machines so that they are held firmly closed without locking devices.

FEEDING MOLTEN GLASS.—G. E. Howard (*Pat. J.*, No. 1565, 1919). Pat. No. 120,744, Aug. 10, 1917. Relates to the feeding of molten glass from tanks, furnaces, or other supply reservoirs, to moulds, etc.

GLASS-SHAPING MACHINES.—Hartford-Fairmont Co., etc. (*Pat. J.*, No. 1566, 1919). Pat. No. 120,907, Nov. 11, 1918. Relates to glass moulding and blowing machines of the rotary table type, and particularly to duplex or multiple machines, and consists of interlocking mechanisms to secure the proper co-ordinate action of the parts and to allow any single element to be operated independently of the others.

GLASS FURNACES.—Burdons, Ltd. and W. M. Burdon (*Pat. J.*, No. 1567, 1919). Pat. No. 121,100, Aug. 9, 1918. Relates to a glowry-hole furnace for reheating glass bottles, etc.

BLOWING GLASS.—M. Gelas (*Pat. J.*, No. 1569, 1919). Pat. No. 11,772, Aug. 14, 1915. Relates to a machine for blowing glass articles, in which means are provided for forming the parison either by blowing as when making narrow-necked bottles, or by pressing as in making wide-mouthed jars.

DELIVERING MOLTEN GLASS.—O. M. Tucker and W. A. Reeves (*Pat. J.*, No. 1572, 1919). Pats. Nos. 121,972 and 121,973, April 10, 1917. Relate to a method of delivering molten metal through an outlet so that a gob or globule of the required size can be cut off and delivered to the mould.

DISCHARGING GLASS.—G. E. Howard (*Pat. J.*, No. 1574, 1919). Pat. No. 122,258, Jan. 21, 1918. Molten glass is delivered from a tank furnace by feeding it from the melting chamber through a relatively small opening or passage during a comparatively long interval of time, raising the level of the glass in the delivery chamber by displacement, and discharging the glass by gravity in a comparatively short time through an opening or outlet of relatively large area. The level of glass in the delivery chamber is raised by lowering into the glass one or more refractory blocks or plungers.

GLASS FURNACES.—T. B. Kitson (*Pat. J.* No. 1576, 1919). Pat. No. 122,672, Dec. 27, 1917. Relates to reverberatory furnaces for glass manufacture, etc.

GLASS FURNACES.—A. F. Peeters (*Pat. J.*, No. 1578, 1919). Pat. No. 123,146, Feb. 11, 1918. Two or more working spaces are connected

with a single melting space, the total cross-sectional area of the working spaces being in excess of that of the melting space. The heating gases pass from the melting space through the working spaces, or vice versa.

BOTTLE-MAKING MACHINES.—L. V. Lockwood (*Pat. J.*, No. 1578, 1919). Pat. No. 123,236, April 26, 1918. Consists of mechanism for forming a bottle neck with an internal groove of the form described in Specification 25440/11. The invention is described as applied to a rotary machine in which a series of five parison moulds are mounted on a table which receives an intermittent movement.

GLASS-ANNEALING LEERS.—J. Keith and G. Keith (*Pat. J.*, No. 1578, 1919). Pat. No. 123,254, June 13, 1918. A glass-annealing leer, through which goods are carried by an endless conveyor, consists of a long tunnel with a long portion inclined upwards from the feeding end, a gas-fired heating chamber at the highest level and a long downwardly inclined discharge part, the end of which is at a slightly higher level than the inlet to the tunnel.

MAKING GLASS BOTTLES, ETC.—Sykes & Sugden, and T. Jackson (*Pat. J.*, No. 1582, 1919). Pat. No. 124,118, June 8, 1918. Relates to the type of turnover machines in which both parison and finishing moulds rotate about a central column, and consists of means for controlling the valves through which suction acts to draw the glass into the neck ring.

GLASS FURNACES.—T. B. Kitson (*Pat. J.*, No. 1583, 1919). Pat. No. 124,273, March 20, 1918. A small auxiliary furnace connected by a short duct with the main furnace, and independently heated (by gas and air), has its outlet flue arranged above the gathering trough so that the escaping gases keep the outflowing material properly liquid. The air may be drawn through a heating flue or through a regenerator.

GLASS FURNACES.—H. C. Ghijsen, etc. (*Pat. J.*, No. 1583, 1919). Pat. No. 124,307, April 9, 1918. In a melting furnace, more particularly adapted for use in filling the bases of electric lamps with molten glass, a continuous stream of metal is maintained by heating a small part only of the raw material, and the quantity required for a filling operation is cut off by a pair of blades and led through a conduit into the base or mould to be charged.

GLASS BLOWING.—A. E. Clegg (*Pat. J.*, No. 1583, 1919). Pat. No. 124,356, July 12, 1918. In a machine for pressing jam-jar blanks intended to be blown subsequently in another mould, the usual spring cover-plate, through which the plunger works, is operated by a cam by means of levers, the ends of which press upon sliding rods. A hand lever mounted on the same shaft as the cam operates the plunger through arms and links. By this arrangement, the springs no longer oppose the motion of the plunger when once the roller rides on the concentric part of the cam, and consequently this motion is easier and more sensitive.

MOULDING GLASS.—F. W. Miller (*Pat. J.*, No. 1586, 1919). Pat. No. 124,957, June 4, 1918. Cameos or other articles of glass or enamel are formed by fusing powdered material in thin metal moulds, the moulds being afterwards dissolved. The depressions of the mould may be filled with coloured material, the mould being filled up with material of another colour to form a background. The moulds may be made of copper and may be dissolved by acid or by electrolysis.

DELIVERING MOLTEN GLASS.—W. C. Blank (*Pat. J.*, No. 1588, 1919). Pat. No. 125,560, Oct. 17, 1918. Relates to delivery devices of the type in which the flow of glass issuing downwardly through an opening in an extension of the melting tank is controlled by varying the air pressure in a vertical vessel disposed above the opening and dipping into the glass. The present invention consists of the combination of pneumatic means for moving a turntable carrying the moulds, actuating the glass-severing shears and operating the valves controlling the air pressure.

GLASS MANUFACTURE.—G. C. Pyle, and Shawbruner, Ltd. (*Pat. J.*, No. 1591, 1919). Pat. No. 126,478, May 13, 1918. In a rotary-table machine, of the type described in Specification 23478/11, in which the parison moulds are raised into the blow-moulds for the filling and pressing operations, two or more parison moulds are combined with each blow-mould and are arranged to come into action on alternate or successive revolutions of the machine.

FORMING SHEET GLASS.—E. Danner (*Pat. J.*, No. 1591, 1919). Pat. No. 126,747, Dec. 31, 1917. Molten metal from the furnace flows over a trough into a chamber heated by burners, and issues in sheet form below a vertically adjustable gate. The glass is received on a heated slab from the lower part of which the sheet is drawn away by means such as that described in Specification 110,642.

BOTTLE-BLOWING MACHINES.—F. W. Knowles, and G. W. Inman (*Pat. J.*, No. 1592, 1919). Pat. No. 126,862, July 16, 1918. Relates to machines in which three or more turnover heads are mounted to rotate on a pillar, or in which the turnover heads do not rotate horizontally, and consists in mounting the blowing mould of each unit so that it can be moved laterally from under the turnover head.

BOTTLE MACHINES.—G. C. Pyle, and Shawburner, Ltd. (*Pat. J.*, No. 1592, 1919). Pat. No. 126,935, May 13, 1918. The invention relates to rotary-table bottle machines of the type described in Specification 126,478, and mainly consists in tappet mechanism for actuating the valves of the pneumatic cylinder which operates the pressing-plunger.

GLASS BLOWING.—A. Dutch Firm (*Pat. J.*, No. 1593, 1919). Pat. No. 127,450, July 29, 1918. Apparatus for making hollow glass articles comprises two horizontal tables, rotatably mounted on pillars, and carrying a number of two part parison moulds and finishing moulds respectively, each mould having two or more moulding spaces, with a vertically-movable frame carrying two or more yieldingly and independently mounted piercing-plungers arranged above one table and a blowing-nipple having two or more nozzles adapted to be moved up and down above the other table.

OPAQUE GLASS.—Corning Glass Works, etc. (*Pat. J.*, No. 1593, 1919). Pat. No. 127,586, May 28, 1919. Relates to the production of a practically opaque glass which has a high transmission for ultra-violet rays, Nickel oxide (NiO) in the proportion of $\frac{1}{2}$ to 12 per cent. is employed in a glass mixture which is substantially free from lime, magnesia, lead oxide, alumina, and boric oxide. Various compositions for barium and zinc glasses are given. Glasses containing only a small proportion of nickel transmit extreme red and infra-red as well as ultra-violet rays. The preferred composition is 50 SiO_2, 16 K_2O, 25 BaO, and 9 per cent. NiO. A small percentage of cupric oxide may be added to reduce the transmission of red rays.

BLOWING GLASSWARE.—J. B. Graham (*Pat. J.*, No. 1594, 1919). Pat. No. 127,995, June 12, 1918. An automatic turn-over blowing machine is constructed with upper and lower tables moving together by a step-by-step motion round a central column. The upper table carries a series of neck and inverted parison moulds, and the lower table carries a corresponding series of blowing moulds. The machine is mounted on a wheeled base running on rails so that it can be brought up to the melting tank, from which the glass is delivered. The severing devices for the glass may be of the kind described in Specification 128,172. The tables move through eight steps, beginning with the dropping of a gob of glass into a parison mould, and finishing with the discharge of a bottle from a blowing mould. The parison moulds are filled in succession, so that eight articles are being produced at the same time.

DELIVERING GLASS.—J. B. Graham (*Pat. J.*, No. 1594, 1919). Pat. No. 127,996, June 12, 1918. Molten metal flowing from an extension of

the melting tank enters a receptacle which is closed at the bottom by a horizontally movable blade. The blade when closed causes part of the charge to accumulate and when opened the stream is released, the excluded mass being temporarily supported by the lateral surfaces of the discharge orifice. The blade is then returned to sever the stream.

MAKING GLASSWARE.—J. B. Graham (*Pat. J.*, No. 1594, 1919). Pats. Nos. 128,170 to 128,173, June 12, 1918. Relates to rotary-table glass-blowing machines of the type described in Specification 127,995, etc.

GLASS DRAWING.—Empire Machine Co. (*Pat. J.*, No. 1598, 1919). Pat. No. 129,211, Jan. 13, 1919. In drawing glass cylinders, the bait is heated to about 200° to 300°F., so that, as the drawing proceeds, it will contract to about the same extent as the glass ring in contact with it. It thus retains a firm hold upon the cylinder and so prevents the escape of air, while at the same time the temperature is not high enough to cause the glass to adhere to the bait. Undercut grooves may be formed in the bait to improve the anchorage of the glass.

GLASS MANUFACTURE.—S. English, and W. M. Gibbons (*Pat. J.*, No. 1599, 1919). Pat. No. 129,508, Sept. 7, 1918. Relates to the manufacture of the glass part of fountain pen fillers, test tubes, etc., from tubular blanks.

DELIVERING MOLTEN GLASS.—J. Forster (*Pat. J.*, No. 1600, 1919). Pat. No. 129,822, July 25, 1918. Relates to apparatus in which the flow of molten metal from the discharge orifice of a melting tank is alternately checked and accelerated by the vertical movement of a plunger immersed in the metal near the orifice.

GATHERING MOLTEN GLASS.—M. Mathy (*Pat. J.*, No. 1600, 1919). Pat. No. 129,947, March 18, 1919. Gathering rods or pipes are formed with an enlarged end of cylindrical or conical form, which merges abruptly at the shoulder into the pipe or rod. The device is stated to promote uniformity in the amount of the gather, irrespective of the depth to which the rod may be immersed. To prevent oxidation, the end of the rod is immersed in a bath of kaolin or clay prior to gathering.

GLASS MANUFACTURE.—M. Mathy (*Pat. J.*, No. 1601, 1919). Pat. No. 130,294, March 18, 1919. Relates to tools for shaping bottle necks by rotation.

GLASS MANUFACTURE.—W. J. Miller (*Pat. J.*, No. 1604, 1919). Pats. Nos. 130,985 to 130,988, Aug. 8, 1918. Relate to presses for moulding glass articles, and to apparatus for discharging the finished glassware from the moulds of a press, etc.

MOULDING GLASS, ETC.—Hartford-Fairmont Co., etc. (*Pat. J.*, No. 1604, 1919). Pat. No. 131,284, July 28, 1919. Relates to machines for moulding plastic substances, such as glass, and particularly to the mechanism for timing the movements of the plungers and tables of the rotating table type of machine such as is described in Specification 120,907. The invention is stated to be applicable also to glass-blowing machines.

BLOWING BOTTLES, ETC.—S. D. Olsen (*Pat. J.*, No. 1605, 1919). Pat. No. 131,391, June 17, 1918. A rotary machine in which the parison moulds are mounted on an upper and the finishing moulds on a lower table is provided with turnover mechanism by which the parison is automatically transferred from one mould to the other.

GLASS MANUFACTURES.—W. A. Whatmough (*Pat. J.*, No. 1605, 1919). Pat. No. 131,532, Dec. 20, 1918. Relates to apparatus for making two vials (or similar vessels) from a length of glass tubing.

DELIVERING MOLTEN GLASS.—O. M. Tucker, and W. A. Reeves (*Pat. J.*, No. 1605, 1919). Pat. No. 131,586, Aug. 5, 1919. In extruding charges from a discharge orifice, pressure is applied to the molten metal

so that "the rate of extrusion is not less than the rate of downward travel of the already extruded glass."

DELIVERING MOLTEN GLASS.—British Thomson-Houston Co., and J. Gray (*Pat. J.*, No. 1606, 1919). Pat. No. 131,756, Sep. 12, 1918. In a machine for manufacturing glassware, more especially bottles, lamp bulbs, etc., predetermined quantities of glass are discharged periodically from a tank or forehearth by a reciprocating displacer which is lowered into the tank to raise the level of the metal. The displacer is preferably conical, and is adjustably mounted so that its depth of immersion may be varied.

GLASS MANUFACTURE.—M. Mathy (*Pat. J.*, No. 1606, 1919). Pat. No. 131,843, March 17, 1919. Relates to blowing bottles, etc.

GLASS-BLOWING MACHINES.—W. McNeilage (*Pat. J.*, No. 1608, 1919). Pat. No. 132,589, Sept. 9, 1918. Relates to rotary-table machines and to means for forming a screw-thread in the mouth of the blank in the parison mould.

MAKING SHEET GLASS.—T. J. McCoy (*Pat. J.*, No. 1608, 1919). Pat. No. 132,649, Oct. 11, 1918. Relates to apparatus for making sheet glass by causing molten metal to flow in sheet form from the melting-tank on to a conveyor.

BLOWING BOTTLES, ETC.—Owens Bottle Co., etc. (*Pat. J.*, No. 1608, 1919). Pat. No. 132,768, July 21, 1919. Relates to the manufacture of bottles having re-entrant bottoms. There is a special contrivance for removing the bottles from the moulds.

ANNEALING FURNACES.—G. R. Hughes (*Pat. J.*, No. 1609, 1919). Pat. No. 132,852, Sept. 21, 1918. Relates to a furnace arranged close to a lamp-workers' bench, and provided with a separate door for each worker. When a door is opened, blow pipes are automatically turned on inside so as to heat the air which enters when the door is opened.

DELIVERING MOLTEN GLASS.—S. D. Olsen (*Pat. J.*, No. 1609, 1919). Pat. No. 132,898, Oct. 3, 1918. Relates to an automatic feed for machines for making glassware, and consists in receiving the stream of metal in a water cooled cup which can be turned over to deliver the charge of metal into an inverted parison mould—thus delivering the hottest portion of the charge into the lower or neck portion of the parison mould.

BLOWING BOTTLES AND JARS, ETC.—A German Firm (*Pat. J.*, No. 1610, 1919). Pat. No. 133,071, June 14, 1917. A preliminary mould is first charged by dipping it in molten glass and sucking the glass into it, then a head or neck mould is applied and a part of the glass in the preliminary mould is raised into the head mould either by further suction or by pressure from below, after which the article is blown in the usual manner.

GLASS BLOWING, ETC.—E. Roirant (*Pat. J.*, No. 1614, 1919). Pat. No. 134,152, March 10, 1919. Relates to automatic apparatus for the manufacture of glass bottles.

TREATING GLASS, ETC.—H. Soar (*Pat. J.*, No. 1614, 1919). Pat. No. 134,160, March 21, 1919. The surface pores of translucent substances such as glass, gems, etc., are impregnated with powdered substances such as ammonium sulphate, sulphur, realgar, etc., with a view to decreasing the amount of dispersion of light whilst increasing the degree of refrangibility. Fluorescent properties may be imparted to glass, etc., by impregnating the surface with a fluorescent powder, such as quinine sulphate.

GLASS BLOWING.—A. A. Mohn (*Pat. J.*, No. 1614, 1919). Pat. No. 134,252, July 31, 1918. In a machine of the turn-over rotary table type, the usual neck, parison and blowing moulds are combined in a single divided hinged mould which is closed round the blowing nozzle. After being charged and inverted the mould is closed by a bottom plate, and compressed air is then admitted through a valve to blow the bottle, etc.

TESTS FOR STRIÆ IN OPTICAL GLASS.—L. E. Dodd (*J. Amer. Cer. Soc.*, 977, 1919). The full title is "Comparison Tests for Striæ in Optical Glass, by the Brashear Converging Light, Direct View Method, the Bureau of Standards Tank Immersion Method, and the Short Range Projection Method". The apparatus used is described, and the results of tests are tabulated and discussed, and finally certain general conclusions are stated.

XI.—CEMENTS, MORTARS, CONCRETE, ETC.

MAGNESIA IN PORTLAND CEMENT.—(*Quarry*, **23**, 36, 1918). A note relating to tests made by the U.S. Bureau of Standards. It was found that increasing magnesia content was associated with a reduction in clinkering temperature of the cements and also (as shown by miscroscopic examination) an increasing size of crystals and granularity and with the appearance of new constituents not present in normal cement; with over 8 per cent. of magnesia, monticellite was found, and with over 10 per cent., spinel in addition. The tricalcium silicate and tricalcium aluminate were not materially decreased when the new constituents appeared, but calcium orthosilicate was decidedly decreased in amount. Below 8 per cent. the higher content of magnesia did not seriously affect any of the physical properties. The larger amounts produced quick initial setting and apparently slow final setting. Below 8 per cent. of magnesia the mechanical strengths of neat and mortar specimens and of concrete were comparable to those obtained with cements having normal magnesia content. Above 8 per cent. the early strength was less, but the gain was consistent with age.

THE SETTING OF PLASTER.—C. H. Desch (*Pot. Gaz.*, **43**, 864, 1918). See TRANS., **18**, 15, 1919.

COMPRESSIVE STRENGTH OF CEMENT-LIME MORTARS.—F. A. Kirkpatrick and W. B. Orange (*J. Amer. Cer. Soc.*, **2**, 44, 1919). Relates to materials, methods and results, the latter being shown in tables and in plotted curves. The conclusions are of limited application, owing to the fact that only one kind of lime, cement, and sand was used, and only one consistency for the mixtures, but these considerations would not change the general relations.

Hydrated lime added to Portland cement mortars in moderate amounts causes an increase of strength due to increase of density. Equal amounts of cement added to the same mortars cause equal or greater increases in strength.

Porosity and water ratio, which bear close relations to the strength of cement mortars, do not define accurately the relation for cement-lime mortars whose strength is governed by density and amount of cement as expressed by the cement-density product.

THE SYSTEM LIME—ALUMINA—SILICA AND ITS RELATIONS TO BLAST FURNACE SLAGS AND TO PORTLAND CEMENT.—B. Neumann (*Stahl and Eisen*, **38**, 953, 1918). A short review of the results of recent investigations on the subject.

Practical applications have been repeatedly made already of the researches, on the lime-alumina-silica system, in connection with the constitution of blast furnace slags, etc. (Mathesius), the constitution of Portland cement clinker (Jänecke), the lime-silica series of minerals (Day, Allen, etc.).

The results of investigation at the Carnegie Institute are briefly as follows: Kanolt determined the melting points of lime 2570°C., alumina 2050°, Fenner and Bowen determined that of cristobalite at 1625°, and that of metastable quartz at 1470°C.

In the lime-silica system four different compounds are formed: 1. Calcium metasilicate, $CaO.SiO_2$, melting point 1540°C., which occurs in two forms, as wollastonite, stable to 1200°C., and as pseudowollastonite, stable between 1200° and 1540°C., the latter only occurs in artificial fusions, including slags. 2. The compound $3CaO.2SiO_2$ at 1475° into $2CaO.SiO_2$ and liquid and has no true melting point. 3. Calcium orthosilicate, $2CaO.SiO_2$. The α—form melts at 2130°C., it passes reversibly into the β-form at 1420°C., and into the γ-form at 675°C. In transition from the β to the γ-form occurs through increase of volume the powdery disintegration well known in Portland cement. 4. Tricalcium silicate, $3CaO.SiO_2$, is unstable and decomposes at 1900° into CaO, and $2CaO.SiO_2$.

In the alumina-silica system only one compound occurs, sillimanite, $Al_2O_3.SiO_2$, which melts at 1816°C. The eutectic sillimanite-alumina with 64 per cent. alumina melts at 1810°C.

In the lime-alumina system four different compounds appear; 1. Tricalcium aluminate, $3CaO.Al_2O_3$, is unstable, decomposing at 1535°C. into CaO and a fused mass. 2. The compound $5CaO.3Al_2O_3$ occurs in a stable and an unstable form. The stable form melts at 1455° and forms with $3CaO.Al_2O_3$ and with $CaO.Al_2O_3$ eutectic mixtures melting at 1395° and 1400°C. respectively. 3 Calcium aluminate $CaO.Al_2O_3$ melts at 1600°C. 4. The compound $3CaO.5Al_2O_3$. The stable form, which melts at 1720°, forms a eutectic mixture with calcium aluminate melting at 1590°, and one with alumina melting at 1700°C. The unstable form occurs but seldom.

In investigating ternary mixtures three further crystallised phases appear, of which two are stable in contact with liquid: 1. Artificial anorthite, $CaO.Al_2O_3.2SiO_2$, which melts at 1550°. 2. The compound $2CaO.Al_2O_3.SiO_2$, which melts at 1590°C. 3. The compound $3CaO.Al_2O_3.SiO_2$, which is unstable at its melting point, decomposing at 1335° into $2CaO.SiO_2$ and $CaO.Al_2O_3$.

In the complete triangular diagram for lime—alumina—silica 14 separate regions of stability are demonstrated and clearly distinguishable. The relations are also well shown by the irregularities of the upper surface of a triangular model.

For practical purposes it would often be desirable to know the composition of the phases when a ternary solution is cooled. Former data in the diagrams indicate only the equilibrium relations between the various phases of the system $CaO.SiO_2.Al_2O_3$. For explanation of these processes Rankin sets forth the theory of phase separation and crystallization in the three component system of Geer (*J. Phys. Chem.*, **18**, 257, 1904). Here the equilibrium diagram is only traced out with the course of crystallization when ternary solutions of $CaO.Al_2O_3$, and SiO_2 are cooled.

Blast furnace slags and Portland cement, since their chemical composition only varies within narrow limits, occupy in the triangular diagram only comparatively small regions; near the lime-silica side of the triangle these are indicated on a diagram. Several curves are given showing relations of melting points, etc., of slags—after J. E. Johnson, jun. (*Met. Chem. Eng.*, p. 363, 1916), and Fulton (*Trans. Amer. Inst. Min. Eng.*, p. 1457, 1912). The blast furnace slags have different composition according as coke or charcoal is used for fuel, the use of coke (with its associated sulphur) involving an increased proportion of lime; the lime distributes itself to the silica and the sulphur in a way which is not well understood, but the more basic the slags, the more complete the desulphurization and also the higher the melting point.

Slags rich in lime have little or no viscosity (like water or quicksilver), and flow out from a ladle in single round drops. Slags rich in silica are very viscous (like treacle or tar), and give long drops and threads (like glass). The temperature at which a highly calcareous slag flows freely is only little above its softening point, but with highly silicious slags the difference between the corresponding two temperatures amounts to 200° to 300°C. Fulton's researches on copper slags illustrate this phenomenon very clearly,

as shown in curves of fusing points, and fluidity.

With coke as fuel for blast furnaces, on account of the necessary desulphurization the slag must keep the lime and silica in the proportion of about 1·5: 1, the slags containing about 34 per cent. of silica, and in order to secure the necessary fluidity of the slag a temperature nearly 200° higher is required than when charcoal is used as fuel. By increasing the silica content to 37 per cent. (with $CaO.SiO_2 = 1·35:1$), the temperature of fluidity is lower, but the desulphurization is insufficient. By bringing the silica content down to 32 per cent. the temperature of the furnace must be raised considerably, and the quantity of slag is increased (about 6 per cent. when the silica is changed from 34 to 32 per cent.), and this again necessitates a further quantity of heat in the furnace; if this necessary heat is wanting the slag becomes stiff, therefore addition of lime above a certain limit no longer improves the desulphurization, because the greater stiffness of the slag outweighs the influence of greater basicity.

Besides lime, silica, and alumina, blast furnace slags contain also magnesia, manganese, iron, and calcium sulphide. These substances lower the melting point and increase the fluidity of the slag. In practice, scarcely any of the slags contain more than 60 per cent. of silica.

The results of the Carnegie Institute investigations also throw light on the question of the constitution of Portland cement and its hardening and setting. The constitution of Portland cement clinker could be quite sharply defined if the clinker represented a complete equilibrium from only the three substances lime, alumina, and silica, which in reality is not the case. In the triangular diagram the region of Portland cement falls completely within the triangle formed by the lines joining points representing the compounds $3CaO.SiO_2$—$3CaO.Al_2O_3$—$2CaSiO_2$, and cement clinker from pure lime, alumina, and silica, burned at sufficiently high temperature, consists of these three compounds. If however, as actually occurs in practice; equilibrium is only approximately reached, free lime or the compound $5CaO.3Al_2O_3$, or both, will also be present.

The divergent view of another investigator concerning the constitution of the clinker is mainly caused by uncertainty as to the existence of tricaleium silicate, Moreover, Jänecke introduced as essential another compound $8CaO.Al_2O_3.2SiO_2$ (alite). Accordingly, with the assumption of the existence of tricalcium silicate the clinker consists of $3CaO.SiO_2$, $2CaO.SiO_2$ and $8CaO.Al_2O_3.2SiO_2$, or otherwise of CaO, $2CaO.SiO_2$ and $8CaO.Al_2O_3.2SiO_2$.

According to the results of the American investigations Jänecke's theory is untenable, for no ternary compound occurs in the region of normal clinker and also various inferences from this theory cannot be brought into harmony with certain practical experiences. The conception of the constitution of cement clinker obtained on the basis of the American investigation of the three substance system is quite evidently simpler and more convincing than all previous attempts at explanation.

Rankin (*J. Franklin Inst.*, **181**, 747, 1916) has still further dealt with Portland cement from this point of view. According to this the following processes happen successively, in the burning. First carbon dioxide is expelled, then $5CaO.3Al_2O_3$ is formed rapidly, and then $2CaO.SiO_2$; then by the taking up of lime are formed (only slowly) $3CaO.Al_2O_3$ and $3CaO.SiO_2$. The speed of formation is increased by the arising of a fluid melt which so to speak acts as flux or solvent. At 1335°C. the eutectic of $2CaO.SiO_2$—$5CaO.3Al_2O_3$—$3CaO.Al_2O_3$ is fluid. With further rise of temperature the formation of $3CaO.Al_2O_3$ increases and $3CaO.SiO_2$ is formed, which with rising temperature is further formed from CaO and $2CaO.SiO_2$, and $3CaO.Al_2O_3$ dissolves in the melt with partial double decomposition with $2CaO.SiO_2$ It is not necessary to go further with the heating, for normal clinker is produced far below the melting point. According to Rankin, starting with the raw materials lime or calcium carbonate, the products at 1000°C. consist of $CaO.Al_2O_3$, SiO_2, at 1000° to 1335° of CaO, $5CaO.3Al_2O_3$,

$2CaO.SiO_2$, and $3CaO.Al_2O_3$, at 1335° to 1450°, CaO, $3CaO.Al_2O_3$, $2CaO.SiO_2$, $3CaO.SiO_2$ and melts, at 1450° to 1650°, CaO, $2CaO.SiO_2$, $3CaO.SiO_2$, and melts, and cold clinker of $2CaO.SiO_2$, $3CaO.SiO_2$, and $3CaO.Al_2O_3$.

Commercial cements always contain small percentages of foreign admixtures, FeO, MgO, alkalies, etc., thus altering the burning temperature as well as the composition.

With insufficient burning, the $3CaO.SiO_2$ is reduced in favour of $2CaO.SiO_2$ and CaO, but the beta-form of $2CaO.SiO_2$ is the cause of rupture.

When mixed with water, finely ground cement sets in a few hours. After setting, the cement continues to harden, and the hardening may proceed for a year. The hardening process has not been clearly traced, but the setting is well understood. Pure $3CaO.Al_2O_3$ and also $3CaO.SiO_2$, mixed with water set very quickly and harden very quickly, but the aluminate more quickly than the silicate, and both form amorphous hydrates. $2CaO.SiO_2$ re-acts with water very slowly and requires a very long time to form a hard mass. The amorphous hydrates in time pass into the crystalline condition. Crystals of calcium hydroxide and crystalline hydrate arise from $3CaO.Al_2O_3$, whilst apparently the crystalline hydrate of the calcium silicate does not occur. The setting of the cement is thus in any case to be traced to hydrating of calcium aluminate, the hardening and strengthening to the hydrating of this aluminate and of the tricalcium silicate.

The tricalcium silicate is therefore evidently the most valuable cementing ingredient; the dicalcium silicate sets and hardens too slowly, the aluminate sets and hardens too quickly, is soluble in water, and has little strength. In the clinker the calcium aluminate serves chiefly as a flux to facilitate the formation of tricalcium silicate (which would be formed from lime and silica at about 1700°C.) at comparatively low temperatures in quite a similar way to that of Rankin.

Bates and Klein (in *J. Franklin Inst.*, **182**, 398, 1916), treat the properties of calcium silicates and calcium aluminates occurring in Portland cement.

PLASTER PASTE AND MAGNESIA CEMENT.—B. Kosmann (*Tonind. Ztg.*, **42**, 103, 115, 123, 137, 1918). Natural gypsum contains 32·58 per cent. lime, 46·49 sulphuric acid (or rather sulphur trioxide) and 20·93 water—or approximately 32·5 lime, 46·5 SO_3, and 21 water. This water is not present as water of crystallization, but persists in actual chemical combination as water of constitution or water of hydration; the admission and reception of this water depend on combination of $Ca(OH)_2$ and H_2SO_4 $(OH)_2$ to form $CaSO_4.2H_2O = CaSO_2(OH)_4$.

That these two molecules of water are present in gypsum in different chemical combination (that is, with different chemical energy), the author announced in 1891 (Ueber die Zusammensetzung wasserhaltiger Mineralien, Verhandlungen der Gesellschaft deutscher Naturforscher 1891 zu Halle a.S.).

Van't Hoff determined the quantity of the more feebly combined water and also ascertained the temperature (107°C.) at which this more loosely combined water went off, plaster being formed. The percentage composition of the doubly hydrated calcium sulphate is made up of 79·07 calcium sulphate, 5·23 more firmly combined water, and 15·70 more loosely combined water; the hemihydrate consists of 38·64 lime, 55·15 SO_3, and 6·20 water.

J. Thomsen found the heat of formation of CaO,SO_3 to $CaSO_4$ to be 84200 units, and the heat of solution $\times$ 4440. He also found for CaO_2H_2, H_2SO_4 to $CaSO_4.2H_2O$ heat of formation 52280, and heat of solution—300; also for $CaSO_4.2H_2O$ to $CaSO_4.2H_2O$ heat of formation 4740, and heat of solution—300. These numbers apply to the work of a kilogram-molecule, and to be referred to absolute weight they must be divided by the corresponing molecular weight. Thus the molecular weight of Estrichgips (Calcium sulphate) is 136, and that of gypsum 172, so for 1 kg. Estrichgips in mixture with 265g water to 1265g double hydrate the development of heat is $4740 \div 136 = 34·8$ heat units. A. Moye gives the value for this as 33·83 heat units; the difference between 33·83 and 34·83 depends on variations in the thermal determinations.

The development of heat occurring with the taking up of water by calcined gypsum (the anhydrous sulphate) is attended with a contraction or diminution of space and therefore condensation; that corresponds with the rule: with the giving out of heat condensation takes place, which attains its maximum with liquefaction of the body.

The solidification resulting from the taking up of water or formation of hydrate depends on the fact that with the small solubility of the gypsum a saturated solution of it soon arises, from which crystals of gypsum join on and build up to a dense felted network.

This process disposes of the heat of solution of the anhydride of —300 heat units as introduction to the formation of crystals now resulting, which is attended by an expansion during the appearance of absorbed heat, to the action of which it is owing that the pasty gypsum mass occupies the very fine cracks and outlines of the mould and becomes attached.

The transformation of anhydrous gypsum into double hydrate is therefore an exothermic process, crystal formation and consolidation of the double hydrate an endothermic process. It is therefore apparent that above the heat of solution of Estrichgips $= +4440$ heat units, that of the anhydride arising from dehydration of the double hydrate $=$ (—300 heat units) was indicated. The total heat action from the two values is 4740 heat units.

There is another source for the appearance of the heat of solution of—300 heat units. Plaster, the hemihydrate with a residue of 6·20 per cent. water of hydration, is more easily soluble than Estrichgips or anhydrous sulphate; according to A. Moye 1kg. of the hemihydrate takes up 0·186 kg. water, giving off 27 heat units. The combining weight of the hemihydrate is: 1 mol. calcium sulphate $= 136 + 1·5$ mol. water $= 27$ gives total 163. The product of the quantity of heat 27×163 gives the molecular heat $= 4401$ heat units, with which the hydration of the hemihydrate is completed. Substracting 4401 from the heat developed in transformation of the anhydride to dihydrate (4740 heat units), the remainder is 339 heat units, corresponding approximately to the Thomsen number of 300 heat units, whose value is negative because this heat is absorbed in the solution of the hydrate.

The expansion and the pressure in the consolidation is greater and stronger with Estrichgips than with gypsum. If therefore it is a question of additions in the manufacture of calcined gypsum, which aim at stretching or consolidation of the mass, the use of plaster is less to be recommended than Estrichgips; it must be designated useless, so far as inert or chemically inactive substances shall form the addition, which shall only act as burden or as filling material, but actually make the gypsum mass only diluted and more fragile.

The increase of volume with the formation of the double hydrate can be ascertained by calculation of the molecular volume on the assumption that the dehydrated or Estrichgips is treated in the condition of greatest density (without pores). The molecular volume is the quotient of the molecular weight divided by the volume weight or volume density (specific gravity).

Van't Hoff determined the specific gravity for Estrichgips $= 2·97$, for plaster or hemihydrate $= 2·75$, and for gypsum or double hydrate $= 2·32$, and the corresponding molecular weights are 136, 163, 172. The molecular volume is therefore for Estrichgips $136 \div 2·97 = 45·8$, for plaster $163 \div 2·75 = 59·2$, and for gypsum $172 \div 2·32 = 74·2$.

The increase of volume for gypsum produced from Estrichgips therefore amounts to $(74·2 - 45·8) \times 100 \div 45·8 = 61·8$ mol. per cent., that is, the linear expansion is $= \sqrt[3]{61·8} = 3·953$ per cent. For gypsum obtained from plaster the increase of volume is $(59·2 - 45·8) \times 100 \div 45·8 = 29·2$ mol. per cent., that is, the linear expansion is $\sqrt[3]{29·2} = 3·079$ per cent.

In other words: The increase of volume in the formation of the double hydrate from Estrichgips is about 21 vol. per cent. greater than from plaster.

In the production of cements, it is a question of the substitution of the

hydration water of the respective alkaline earthy salts by the equivalent quantity of other hydrated salts capable of combination, therefore these cements can be produced of stronger quality the larger the quantity of the strengthening salt can be added to the salt used to start with.

A serviceable added material must be supplied, such that it fulfils its purpose in two directions: (1) It enters into the gypsum-cement in place of the water present in the double hydrate or necessary hydration water with quantity corresponding to its combining weight, and (2) it causes by its entry in the signified quantity by weight an extension of the gypsum mass without lessening the strength of the set gypsum through the new formations depositing between the crystals of gypsum or growing with them, crystalline or colloidal-amorphous.

For works practice is to be born in mind a circumstance which appears disturbing, and has already been publicly discussed, namely, the uneven quality of the calcined gypsum with regard to its water content or complete dehydration, and the difficulties in the working of such unequal material.

This phenomenon is a problem of plaster manufacture, the wholesale trade of which has to be satisfied with practically attainable performances, without being made responsible for possible bad working of results produced in chemical testing laboratories and too ideal condition of structure striven for.

The practical production of such mixtures of plaster with other bases or salts for the purpose of production of higher strength and durability has made them useful as plaster cements. This name, also on account of looseness general in technical colloquial usage, has changed in association with the properties of true hydraulic cements, and is not quite suitable; for it is here not so much a qustion of mixtures of basic oxides of alkaline earths or their silicate compounds, which in sintered and thereupon ground condition in consequence of the common and simultaneous absorption of water come into reciprocal action and in mutual decomposition are led to new formations of very wide operation, but rather of the reviving of a sulphate limited in water absorption after moderate heating, the properties of the original salt suiting themselves to earthy bases or salts.

For the works production of plaster cements three earthy bases or their salts come especially into consideration; quicklime, magnesia, and alumina, or their sulphates as alum and aluminium sulphate.

Calcined lime appears for the purpose of saturation of the hydrated gypsum (whether plaster or Estrichgips) as the most suitable addition material, since it withdraws from the double hydrate the water of hydration in virtue of its great heat of formation and is deposited in this place in the form of calcium hydrate. The combination forming can be represented by the formula $CaSO_4+2Ca(OH)_2$; in this arrangement the double salt completely follows the natural mineral polyhalite, of the composition $K_2Mg(SO_4)_2+CaSO_4.2H_2O$, which occurs in the bottom layers of rock salt beds.

Quick lime (calcium oxide) absorbs from 1 to 8·5 molecules of water in slaking, with development of 15400 heat units; 15400 heat units of the molecule-kilogram correspond to 275 heat units from 1 kg. quicklime. This development of heat applies to the whole course of the slaking (or absorption of water); the latter proceeds only to the formation of the first stage of hydration, the monohydrate, so the development of heat amounts to $15400 \div 74 = 222$ heat units for 1 kg., 74 being the molecular weight of calcium hydrate. If therefore by addition of two molecules quicklime to the doubly hydrated gypsum its two molecules of water are withdrawn, two molecules of calcium monohydate are produced, forming a disconnected solid mass, which first give off its water of hydration at 130°C.

The two compounds, doubly hydrated calcium sulphate (gypsum), and calcium monohydrate, are subject to the same temperature influences in their drying and in their power of resistence with regard to weathering.

In the mixing of gypsum with calcium hydrate in solid ingredients, one molecule anhydrous gypsum becomes mixed with two molecules quicklime, or 136 parts by weight with 112 parts, which is 55 to 45 in 100 parts; the latter give 59·4 parts calcium hydrate, so that one kg. calcined gypsum with 1·08kg. calcium hydrate gives 2·08kg. of plaster cement. Since the development of heat in the transformation of anhydrous gypsum to double hydrate amounts to 34·3 heat units, it results that upon one kg. calcined gypsum by addition of 818g. quicklime, in the conversion to 1·08kg. monohydrate, a development of heat of $818 \times 222 \div 1000 = 181$ heat units are added, therefore the heat development of the double hydrate of gypsum is increased more than five-fold.

As serviceable additions to lime or in its stead can be used only chemically active metallic or earthy oxides, which at the same time serve as colouring material, as iron oxide (English red), oxides of zinc, cadmium or manganese, alumina, etc.

Prepared chalk (or whiting) is a thoroughly unsuitable addition.

The use of lime-plaster cement can only be satisfactory in dry climates or dry interiors; these conditions are fulfilled in lands like Egypt. In zones with moist and cold nights and much deposition or in places impregnated with vapour this cement is bad.

Magnesia, which is produced from magnesium chloride lye, or calcined magnesite, or from the latest product, artificial magnesite, is to be recommended on similar grounds of chemical suitability like calcium hydrate as a suitable earthy base for production of plaster cement; for it forms a monohydrate, $Mg(OH)_2$, which is a disconnected solid mass capable of little further absorption of water. The formation of this hydrate develops only 3100 heat units in the molecule kilogram, therefore in its heat effect it remains far behind the action—strength and density of the substance produced—as in the case of lime-plaster cement.

It is also to be supposed that a partial decomposition takes place between calcium sulphate and magnesium hydroxide, a small part of the magnesia being sulphated and so a double salt of calcium and magnesium sulphates formed.

This magnesium sulphate (poor in water) with one molecule H_2O, of the formula $MgSO_2(OH)_2$, occurring in nature as kieserite in the Stassfurt deposits, is soluble with difficulty, but with its high heat of formation = 6980 heat units and the heat of solution = 13300 eagerly absorbs water from the air to be gradually transformed into Epsom Salt, $MgSO_4 + 7H_2O$, which dissolves with a negative development of heat = 3800 heat units; a very easily soluble salt is thus formed, which is known in efflorescenses from masonry. In this process lies the small stability of magnesia-plaster cement and the danger of its commencing destruction.

In similar manner as with quicklime are for magnesia-plaster cement according to the formula $CaSO_4 + 2Mg(OH)_2$ mixed in solid ingredients 136 parts anhydrous gypsum and 80 parts magnesia, or 62·9 and 37·1 parts respectively in 100, which after absorption of hydration water become 54 anhydrous gypsum and 46 magnesium hydroxide. To 1 kg. anhydrous gypsum will be needed therefore 0·59 kg. magnesia to produce (with absorption of water) 1·85 kg. magnesia-plaster cement.

The increase of heat in this mixture on 1 kg. anhydrous gypsum for addition of 0·59 kg. magnesia,—since 1 kg. magnesia in conversion to hydroxide develops $3100 \div 40 = 77·5$ heat units—amounts to $77·5 \times 59 \div 100 = 45·7$ heat units.

Reference is also made to a patent process according to which quicklime and magnesium sulphate are mixed at a low heat and then dried at 100—150°C. Also to the author's process of mixing quicklime with iron vitriol, and oxidizing the iron salt by means of hydrogen peroxide.

Potash alum of the formula $K_2Al_2S_4O_{16} + 24H_2O$, in hydrated formula the molecule $H_4K\ AlS_2(OH)_{20}$ with the combining weight 949, is an acid-reacting salt of strong water-withdrawing properties.

The heat of solution of aluminium sulphate, $Al_2S_3O_{12},18H_2O$, in a solution of potassium sulphate=—7960 heat units, and the heat of solution of potash alum (at 18°C.) is—20240 heat units. At 120°C. the hydration water of potash alum begins to escape, which is not very far from the 128° at which gypsum (doubly hydrated) gives off its hydration water.

Reference is made to the oldest recipe for preparation of marble plaster (or marble cement) in Muspratt's Techn. Chem. (1892), article Calcium; marble plaster contains 136 parts anhydrous plaster and 76 parts alum, the latter including 34 parts water, making altogether 212 parts; in 100 parts are 64·0 anhydrous gypsum, 20 anhydrous alum, 16 water; 1 kg. anhydrous plaster therefore yields by addition of 562g. alum 1·562 kg. marble plaster.

The magnesia cement known as "Sorel Cement" or "Alboin" consists of a mixture of magnesium chloride, $MgCl_2+6H_2O$, and magnesia. The chloride gives up 3 of its 6 molecules of hydration water to the magnesia to form magnesium hydroxide, while the remaining 3 molecules of water evaporate. The magnesium hydroxide becomes firmly connected with the dehydrated magnesium chloride to form a solid double compound; for the magnesium chloride with its heat of combination of 150010 heat units exerts a dissolving and therefore uniting influence on the hydroxide, the latter being a hardening body. The product has the formula $MgCl_2.3Mg(OH)_2$.

The same product may be obtained from the end lye in the manufacture of potassium chloride; the lye contains magnesium chloride. A lye of 30°B. contains in 100 parts 30 parts $MgCl_2+70$ parts H_2O, the latter including 34 parts hydration water and 36 parts water of solution. In this solution by further evaporation of water and acid with progressive concentration to 40-42°B. is formed a compound $MgCl_2.3Mg(OH)_2$, which is composed of 35·3 per cent. $MgCl_2$, 44·04MgO, 20·07H_2O. The combining weight of the double compound is 269, that of the hydrochloride $MgCl_2.6H_2O$ being 203. The interchange of heat is thus represented:—

$$\underbrace{\underbrace{\begin{array}{c}MgCl_2.6H_2O+3MgO\\ 183980\text{ heat units}\end{array}}_{183980}\rightleftharpoons\underbrace{\begin{array}{c}MgCl_2+3Mg(OH)_9\\ 151010+3\times3100\end{array}}_{160310}}_{23670}$$

Therefore 23670 heat units have been liberated in this transformation, which at the same time signifies a loss of heat, equal to that developed in the taking up of the first 3 molecules of H_2O.

Magnesia cement is distinguished by its property of taking into admixture up to an equal weight of foreign material chemically inactive (or nearly so) without injuring its strength; certain water-absorbing substances, as chalk, increase the strength, in any case promoting the setting; substances of this class include powdered marble, kieselguhr or precipitated and then calcined silica, sawdust, etc. Xylolite is thus prepared from sawdust. The magnesia cement has been much used as a mortar material for outside decoration, etc.

CALCIUM HYDRATE, CEMENT HYDRATE, ETC.—G. Hall (*Tonind. Ztg.*, **42**, 119, 1918). A discussion of German patents 293825, 300397, and 301118, relating to limes and cements. It is concluded that the first contains nothing really new, and the others are not entirely novel.

TESTS WITH SANTORIN EARTH MORTARS.—Calame (*Tonind. Ztg.*, **42**, 131, 1918). Includes chemical analyses, with results of tests for crushing strength, etc.

HARDENING OF CEMENT AND CEMENT MORTARS.—(*Tonind. Ztg.*, **42**, 187, 1918). A brief review of report by Burchartz on work which extended over ten years, with some general conclusions. The specific gravity of test-pieces left under water increased regularly with increasing

age up to ten years, the maximum being attained in five years only in individual cases. Air test-pieces decreased in weight in the beginning for about a year, and then increased progressively with age. With pure cement these decreases in weight were rather greater than with mortars.

The tensile strength of pure cement under water—apart from the somewhat irregular course between 28 days and 2 years—increases up to 5 years by about 25 per cent., and then remains steady or goes back a little. Under air it progresses in the beginning from 7 days (at which stage it is considerably below that of the water trials) up to 28 days very strongly (about 50 per cent. with normal and about 30 per cent. with higher water addition), then decreases strongly up to 2 years (about 10 or 15 per cent.), and then again progresses very strongly (up to 10 years about 70 per cent. against 18 per cent. with water trials). The tensile strength of air trials will increase briskly even after 10 years.

The tests with normal and higher water addition show, under water, almost the same behaviour.

Comparatively quicker and also more regular is the growth of strength of the mortar trials. It is stronger with air-trials than with water-trials, the average increase of strength up to 10 years amounting to 116 per cent. for water trials, and 165 per cent. with air-trials.

The increase of strength of trials with higher water addition is smaller than for those mixed to normal stiffness, the behaviour of water trials being in this respect more unfavourable than that of air trials. The difference in strength becomes with age greater in both cases. The increase in strength after 10 years amounts to 126 or 106 with water-trials, and to 171 or 160 with air-trials, per 100 parts of the 7-days strength.

Similar particulars are given with respect to crushing strength.

PORTLAND CEMENT TESTS.—(*Tonind.Ztg.*, **42**, 277, 1918). Results of mechanical technical tests at Vienna by Hanisch. Particulars are shown in a table, with reference times of setting and hardening, specific gravities, strengths, etc.

HIGH MAGNESIA IN PORTLAND CEMENT.—K.R. (*Tonind. Ztg.*, **42**, 431, 1918). A short note taken from *Chem. Tr. J.*, Oct., 17.

PLASTER CLINKER.—A. S. (*Tonind. Ztg.*, **42**, 442, 1918). A brief reference to Henrivaux's invention of glass bricks and glass plaster, and their uses for building purposes.

PLASTER IN CERAMIC FACTORIES.—(*Tonind. Ztg.*, **42**, 457, 1918). A short discussion, to which is appended a method for determining the quantity of plaster necessary with 100c.c. water to make a mixture suitable for casting.

COMPARATIVE TESTS OF REINFORCED CONCRETE.—H. Nitzsche (*Tonind. Ztg.*, **42**, 499, 511, 1918). Results of tests for strength, elasticity, etc. The concretes were prepared from gravel and pumice respectively.

VALUATION OF PLASTER.—E. Link (*Tonind. Ztg.*, **42**, 525, 1918). A short note on the importance of valuation.

LIME HYDRATE—CEMENT HYDRATE.—D. J. Mühlen (*Tonind. Ztg.*, **42**, 515, 693, 1918). Refers to new mortar materials described in German patents 293825, 300397, and 301118.

CEMENT—LIME—MORTARS.—(*Tonind. Ztg.*, **42**, 599, 1918). Results of tests for strength, etc., of various mortars after 7 and 28 days.

UNIFORMITY IN PRODUCTION OF CEMENT.—E. Schulze (*Tonind. Ztg.*, **42**, 676, 1918). A short note. In the cement industry the product is assumed to have uniform composition and of course always the same properties. The author points out that the literature of the subject gives no proof of this. For suitable information as to whether it suffices to test the raw-meal merely for the content in calcium carbonate, he investigated

clinker at intervals of seven days, and gives the mean of two concordant analyses:

Insoluble	0·46	0·37	0·31	0·41	0·58
SiO_2	20·53	20·56	20·80	20·62	20·71
Al_2O_3	7·43	7·42	7·71	7·50	6·73
Fe_2O_3	2·56	2·57	2·96	2·90	2·95
CaO	65·75	65·63	65·34	65·65	65·63
MgO	1·97	2·12	2·08	1·87	1·82
SO_3	1·05	0·89	0·75	1·06	1·06
Loss on ignition	0·65	0·70	0·34	0·43	0·76
	100·40	100·26	100·29	100·44	100·24

The small differences are no more than might arise from differences in the raw materials from week to week, and it is not surprising that the strength showed a like agreement. The ascertained time of setting, however, showed no satisfactory uniformity.

WEATHER-PROOF COLOURED PLASTER.—H. Sachse (*Tonind. Ztg.*, **42**, 702, 1918). Mineral colours which are in themselves weather proof, are often found to become in time diluted or shaded off when used for colouring plaster. To prevent this the author recommends the admixture of hydraulic substances such as blast furnace slags, trass, puzzuolana, or sands with soluble silica. The effective agent in all these additions is the soluble silica, which combines with lime to form insoluble calcium silicate, and thus averts the changes on the surface.

INVENTION OF PORTLAND CEMENT.—Neumann (*Tonind. Ztg.*, **42**, 709, 1918). Review of a book by F. Guietmeyer, published in Berlin about six years before, in which it is stated (on the authority of Roman writers) that for improving mortars pulverized crucibles, puzzuolana, and (later) trass were known to the Romans. The most essential part of the invention of modern cement is English.

NEW WOOD-CONCRETE.—(*Tonwar. Ofen. Ztg.*, **42**, 85, 1918). A brief note on a new invention available for building houses, etc.

COLLOIDAL TRICALCIUM ALUMINATE.—A. J. Phillips (*J. Amer. Cer. Soc.*, **2**, 708, 1919). An account of an elaborate investigation made with respect to its behaviour with large and small amounts of water and to the alteration in its condition caused by the addition of several salts, in order to obtain some idea as to the way in which the set of a normal cement would be affected under similar conditions.

Tricalcium aluminate, with a large excess of water, forms a suspension containing small amounts of coarsely dispersed and molecularly dispersed material, the major portion being dispersed to a degree comparable to those colloid suspensions which readily pass through a filter, do not diffuse or dialyze, show the development of the Tyndall cone, and are positively charged. The colloidal aluminate is not coagulated by heat but is coagulated by freezing, and its properties in general resemble those of the sols formed from the metallic oxides Fe_2O_3, Al_2O_3, Cr_2O_3. With the restricted amounts of water used in cement pastes, the aluminate is converted into and remains as a gel, at least during the first 24 hours after mixing. The rate of dispersion of tricalcium aluminate to the gel state is influenced by its previous exposure to moisture, the amount of heat developed during hydration, etc. The rate of coagulation is affected by the amount of dispersion effected, the adsorption of undissociated salt, the fineness and set of the plaster (when plaster is added), etc.

CAUSE OF UNSOUNDNESS IN CEMENT.—B. F. Erdahl (*Concrete, Cement, Mill Section*, **14**, 27, 1919). From considerations enumerated it is concluded that the cause of unsoundness is under-burning, with the formation and subsequent decomposition of $2CaO.SiO_2$. See abstract in *J. Amer. Cer. Soc.*, **2**, 673, 1919.

ALKALIES IN CEMENT CLINKER: THEIR RELATION TO THE SETTING TIMES.—B. F. Erdahl (*Concrete, Cement Mill Section*, **15**, 17, 1919). From the results of his tests the author draws conclusions as follows: The alkalies exist in clinker and cement mainly as readily soluble K and Na sulphates, and as slowly water-soluble double sulphates of the alkalies and lime; the smaller part of the alkalies in clinker and cement exist as water-insoluble or very slightly soluble alkali slags (silicates) consisting chiefly of Na compounds. Traces of K and Na carbonates may be present in clinker and cement, but hardly enough to affect their physical properties. The alkali sulphates and silicates have a somewhat quickening influence on the setting time of cement; the alkali sulphates are also detrimental to the free use of gypsum as a retarding agent as a smaller quantity must be added to keep within the 2 per cent. SO_3 of the specification. The alkali carbonates are very dangerous to the setting properties of cement, but are not often found in large amounts. Alkalies have no determining effect on the soundness of cement.

CAUSES OF UNSOUNDNESS IN PORTLAND CEMENT.—G. A. Rankin, and others (*Concrete, Cement Mill Section*, **15**, 33, 1919). Discussion of article by B. F. Erdahl. See abstract in *J. Amer. Cer. Soc.*, **2**, 918, 1919. Erdahl's conclusions are severely criticised by Rankin, Bates, and others. Erdahl replies, and promises further evidence.

FORMATION AND PROPERTIES OF BLAST FURNACE SLAG AND PORTLAND CEMENT.—(*Genie Civil*, **73**, 512, No. 26, 1919). See abstract in *J. Amer. Cer. Soc.*, **2**, 919, 1919.

METHODS OF FUEL CONSERVATION IN CEMENT MILL OPERATIONS.—E. Ashton (*Concrete. Cement Mill Section*, **13**, 45, 1918). See abstract in *J. Amer. Cer. Soc.*, **2**, 498, 1919.

CEMENTS PRODUCING QUICK-HARDENING CONCRETE.—P. H. Bates (*Concrete, Cement Mill Section*, **15**, 9, 1919). Paper presented at the 1919 meeting of the American Society for Testing Materials. See abstract in *J. Amer. Cer. Soc.*, **2**, 756, 1919.

CEMENTS.—B. Baarnhielm (*Pat. J.*, No. 1570, 1919). Pat. No. 121,728, Oct. 30, 1918. Ground ashes of burnt alum-slate are mixed with Portland cement. The proportion may be of equal parts or the ashes may be in greater proportion.

TREATING CEMENTS.—W. E. Windsor-Richards (*Pat. J.*, No. 1572, 1919. Pat. No. 121,986, Dec. 4, 1917. Clay, preferably dried and powdered, is mixed with ground Portland or like cement to form a moulding composition. The clay may be china clay, ball clay, or ordinary clay or fire-clay. The mixture may contain asbestos or other fibre. An example is:—Portland cement 30 parts, waste asbestos fibre 15, clay 10. Articles moulded from the composition may be impregnated with a bituminous liquid as described in Specification 3364, 1915.

WATERPROOF CEMENTS, ETC.—H. M. Olson and F. J. D. Westell (*Pat. J.*, No. 1580, 1919). Pat. No. 123,695, Sept. 26, 1918. Cementitious material which sets in water and has an alkaline reaction is rendered waterproof by spraying into it, during the grinding process of its manufacture or during re-grinding, an oleaginous or bituminous substance. The cement may be Portland cement, lime, gypsum, hydraulic lime, natural cement, oxychloride of magnesium, alkaline silicate, etc. The waterproofing substance may be animal, vegetable, or mineral oil, either liquid at the ordinary temperature, or solid or semi-solid, such as wax, tallow, or paraffin; or it may be natural or artificial bituminous material, viscid when heated or dissolved in a solvent such as mineral oil or any of the fatty acids. A preferred mixture is 75 parts residue mineral oil and 25 parts beef fat or stearine. The waterproofing material is added in quantity insufficient to destroy the alkaline properties of the cement. A preferred proportion is 1 per cent.

ADHESIVES.—T. Pickard, A. Sherlock, J. A. Callcott, and E. Smith (*Pat. J.*, No. 1583, 1919). Pat. No. 124,302, April 5, 1918. An adhesive cement for mending ceramic, glass, and other articles, consists of isinglass boiled in water to the consistency of cream, to which is added methylated spirit equal in amount to the isinglass. The cement is hard when cold, but can be readily spread when warm.

TREATING CEMENTS AND MORTARS.—C. Catlett (*Pat. J.*, No. 1591, 1919). Pat. No. 126,646, May 9, 1919. Calcium oxychloride and similar oxy-salts are produced by combining a salt and oxide in such proportions and under such conditions, that the material sets and can be pulverized and stored, but on the addition of excess of water dissociates into its constituents. In an example: to 100 parts of quicklime are added 60 parts of commercial calcium chloride dissolved in 50 parts of water. The mixture sets to a substantially dry friable mass which is ground and can be stored. The proportion of chloride may be varied, but preferably lies between 25 and 35 per cent. of the mixture, although the percentage may be as low as about 2, and as high as will combine with all the lime. The presence of magnesium salts in the lime and chloride is not objectionable. The powder is added to Portland cement or lime concretes, usually in proportion of $1\frac{1}{2}$—5 per cent. Calcium hydrate and chloride may be added separately to the Portland cement, and in the case of lime mortars the chloride may be used alone.

CEMENTS.—F. D. Mulligan (*Pat. J.*, No. 1596, 1919). Pat. No. 128,452, July 31, 1918. A compound to be added to ordinary cement to strengthen it and render it waterproof consists of thoroughly slaked lime and raw linseed or equivalent oil of the class known as drying oils. An example of proportions is: 3 oz. of oil to 20 oz. of lime added in the proportion of $\frac{1}{2}$ oz. of the compound to one pound of sand and ordinary cement. The ingredients may be mixed with water to make a wet form of the cement, or they may be dried and made into a dry powder.

PORTLAND CEMENT.—W. S. Akerman (*Pat. J.*, No. 1597, 1919). Pat. No. 128,750, July 2, 1918. Relates to the production of cement from raw marl composed of limestone and shales.

CEMENTS.—Sir G. J. Scott-Moncrieff, and J. Hines (*Pat. J.*, No. 1604, 1919). Pat. No. 131,164, Aug. 21, 1918. About 40 parts of oil shale residue and 40 parts of Norfolk chalk are ground together and clinkered for the manufacture of cement, which is then ground and mixed with 20 parts of raw oil shale to form a waterproof cement. The product may be used for making roads, flooring, roofing, walls, or for constructing culverts, etc.

ARTIFICIAL STONE.—J. Waine (*Pat. J.*, No. 1607, 1919). Pat. No. 132,356, Sept. 12, 1918. Powdered hard stone, such as trap, granite, quarts, or limestone is mixed in volume proportions thus: 100 powdered stone, 15 to 30 Portland cement, 25 sodium silicate, 75 water. The mixture is worked into a stiff paste, left to stand for 48 hours, and moulded.

POTASSIUM SALTS; CEMENTS.—A. C. Auden (*Part. J.*, No. 1609, 1919). Pat. No. 132,855, Sept. 23, 1918. Relates to the production of white cement and potassium salts from minerals such as felspar, mica, micaceous schist, muscovite, pegmatite, china-stone, glauconite, and zeolites, such as those found in a basalt matrix.

ARTIFICIAL STONE, ETC.—A. Fried, and Van Den Daele & Sohn (*Pat. J.*, No. 1614, 1919). Pat. No. 134,230, Oct. 24, 1919. An aggregate for making artificial stone is made from fine waste materials, such as slag, infusorial earth, earths, ground stone, sand, ashes, fibres, sawdust, and a binding material, such as lime, cement, gypsum, glue, oil, resin, and lyes, and the product is formed, for example, by pressing or shaking, into any desired shape or size of particles.

CEMENTS FOR SPARK PLUG ELECTRODES.—H. F. Staley (Report No. 53 of the National Advisory Committee for Aeronautics, p. 33, 1919). When exposed to the high temperatures of the aeroplane engine cylinder, the nickel electrode wire fixed by cement in the porcelain is often rapidly eaten away by oxidation. A cement composed of silicate of soda and raw kaolin has been found to give the least trouble in that direction, but elimination of the cement and use of a mechanical seal at the top of the porcelain is very desirable. It is believed that the porcelain recently developed by the Bureau of Standards meets the requirements involved in such a change.

CAUSE OF UNSOUNDNESS IN PORTLAND CEMENT.—B. F. Erdahl (*Concrete, Cement Mill Section*, **15**, 51, 1919). A continuation of a previous discussion. The author discusses the embedding theory, according to which unsoundness is due to particles of free lime embedded in fused particles of clinker. All cement clinkers contain free or uncombined lime in the clinker. But $3CaO.Al_2O_3$, $2CaO.SiO_2$, and compounds of Fe, Mn, MgO, and the alkalies exist enclosed in a magma of fused $3\ CaO.SiO_2$. These compounds, like free lime, tend to hydrate when gauged with water. The finely ground limestone is evenly distributed through the raw mixture, and becomes calcined before reaching the clinkering zone, the resulting lime forming a dry powder consisting of extremely small particles, In the clinkering zone most of the lime takes part in the chemical combinations, the remainder going into solution or into a segregated viscous state rather than into the form of nuclei. When the clinker is ground some of these very small particles will be liberated but a great many remain embedded in the clinker, being too minute to be reached by mechanical means. This will be the case with all cements both sound and unsound. If the lime particles hydrate on addition of water, the soft-burned clinker should prove sounder than the hard-burned, but the contrary is known to be true. If the particles do not hydrate in the "time of set" pat, investigators who favour the embedding theory assume that hydration will occur in the boiling test. But it is doubtful whether any more hydration of free lime takes place at 100° than at 20°C. This can be proved by making a regulation pat of a sound cement, allowing it to set, and then submitting it to the boiling test. If it is then ground to a fineness equal to that of the original cement and another pat made, it will set. If it is then boiled it will pass the test. This experiment shows that unhydrated compounds existing in the boiled pat, but partly liberated through the second grinding, hydrate under the second gauging and cause a set. These unhydrated materials existing in the original pat consist of both silicate compounds and free lime. The quickly acting $3CaO.Al_2O_3$ has probably become fully set the first time. The second set is then probably due to setting of unhydrated silicates. In grinding, the clinker particles will separate along the lines of least resistance formed by the lime particles, which will thus be released, and hydrated on addition of water. Unsound cement will cure in air-tight vessels inaccessible to moisture, a fact which indicates that embedded lime is not the cause of unsoundness. In the cement industry "overburned clinker" means exceedingly hard-burned clinker. From a chemical standpoint overburning refers to the chemical condition in the clinker when volatilization of essential constituents takes place, not to a physical condition. Unsoundness in underburned cement is not due to free lime, but to $2CaO.SiO_2$, which is very slow setting. The first set in the experiment mentioned was due to $3CaO.SiO_2$ and $3CaO.Al_2O_3$, which set more quickly than $2CaO.SiO_2$ does, and the latter was the cause of the second set. These processes would cause unsoundness when the cement was actually used. The degree of unsoundness thus depends on the proportion of $2CaO.SiO_2$ present, and this depends on the burning temperature, so that unsoundness is most effectively prevented by the adoption of a higher clinkering temperature.

UNSOUNDNESS IN CEMENT.—R. K. Meade (*Concrete, Cement Mill Section*, **15**, 70, 1919). Observations based on the author's practical

experience. Neither the free lime theory nor the "dusting clinker theory is entirely acceptable. Gypsum, plaster of Paris, or calcium chloride added to cement often make it sound. All the cement theories explain some things well but others not at all. For fuller abstract see *J. Amer. Cer. Soc.*, **2**, 1022, 1919.

MODERN AUTOMATIC SHAFT KILNS.—(*Tonind. Ztg.*, **40**, 105, 1916). Article on the advantages of the Taifun type of shaft kiln. The names of certain firms are given who have rebuilt their shaft kilns on this principle. It is claimed that the open arrangement for discharging is an undoubted advantage. A Taifun kiln of 2200 mm. diameter gave the same results as a rotary grate kiln having a diam. of 2300 mm. In order to be able to judge clearly of the results of running, average figures only, from a long period, should be given, as well as the chemical composition and physical properties of the raw material and fuel. At one works, a month's average variations in output were from 210 to 170 casks of 170 kilos each for a day's working of the kiln (For 210 casks, fuel consumed, 24 kilos coke slack; heating power 6500 calories; average ash content of coke 15%; percentage of fuel per cask, 14·1%. For 170 casks—fuel 38 kilos, calorific power 5300; ash 25%; fuel per cask 22·3%). The composition of the raw material used and other details are given.

The working of the Taifun kiln may be interrupted without detriment to the output—a great advantage over other types of kiln. How little it was effected by stoppages, is shown by the fact that, in 1915, six kilns were worked for 4 months, day-shift only and with stoppage of 24 hours on Sundays. Cooling every night increased the fuel consumption by about one-fifth of the usual. On the other hand, the output was only 10% less than that of the average. A description of the kiln follows. It is charged and discharged automatically. The arrangement for discharging consists, in the main, of two horizontal rollers through which the clinker passes in pieces of from 1 to 12 cm. diameter.

When working is to be suspended, the induced draught is first stopped, then the blast. At the beginning of the next shift, the kiln is worked for about ¼ hour with induced draught only, in order to brighten up the fire and, as soon as this is hot enough, the blast and automatic filler are set going. In ½ to ¾ of an hour at the most, the kiln is in full work, although it remained without attendance during the shift not worked. The success of modern shaft kilns is due to the suitable working together of induced draught and air blast; in a lesser degree, to the manner in which the discharging apparatus is constructed. Experiments lead one to hope that even the raw powder will be successfully burned without having been pressed beforehand. P.W.T.

SOFT SOAP AS AN AGENT FOR RENDERING CEMENT-MORTAR AND CONCRETE IMPERVIOUS TO WATER.—W. Schutze (*Tonind. Ztg.*, **40**, 80, 1916). A few remarks on the impermeability of cement-mortar and concrete, with particular reference to the effect of soft soap on both. Soft soap combines with the lime in the mortar to form an insoluble lime soap. For concrete, a potash-soap—the ordinary soft soap—can only be used. Soaps containing soda are not suitable. For preparing mortar, 1—2 kilos of soft soap are dissolved in 100 parts of water: a stronger solution is not recommended. The solution must not be used as a coating to finished concrete goods, as it has been found not to be durable. For cement roofing tiles and for pipes this simple method is an excellent one. P.W.T.

THE ADDITION OF GYPSUM TO CEMENT.—S. Stein (*Tonind. Ztg.*, **40**, 140, 1916). The standard maximum quantity of gypsum is 3%, but with pure gypsum not containing anhydrite, usually less than 3% will do. Cement is often slow-setting with 1—2% gypsum, but not so when the gypsum contains anhydrite, as the latter has no effect on the time taken for setting. If 3% had to be added, a mixture containing 60% anhydrite, for example, would require the addition of 7·5% of gypsum, in order to obtain a slow-

setting cement. But the increased addition of sulphates to a cement may lead to the destruction of concrete under water. Gypsum containing anhydrite should, therefore, not be used.

A table is given showing the effect of various quantities of pure gypsum, free from anhydrite, on Portland cement. The highest crushing strength, after 28 days, is shewn with a gypsum content of 5%. With increasing quantities of gypsum the resistances are, at the commencement of the periods of testing, lower; after three months they decrease gradually. With 6%, after 3 days, the tensile strength is nil; after 7 days, the 7% is also nil. After 3 months, cement with 10% gypsum, shows 29—0 and 254·0 tensile and crushing strength respectively; but, owing to the low resistances at the beginning, could not be used in practice.

Other cements with a larger gypsum content also show better resistances, but it would be a failure to attempt to improve the quality in this way. The fewer sulphates a cement contains the better it resists the action of water containing salt: the way to obtain greater solidity is by good and even burning, thorough grinding of the clinker and by not having too low a lime content. P.W.T.

JOINTING OF CAST IRON WATER PIPES WITH PORTLAND CEMENT.—(*Tonind. Ztg.*, **40**, 101, 1916). Favours the use of Portland cement for the jointing of socket-joints, rather than that of lead. Has been used in many towns in the U.S.A., and found to be cheaper and to last longer than lead. The cement acts as an insulator; the cost is less, the work is easier and time is saved. A description of the method of using is given. P.W.T.

PLASTER AS A BUILDING MATERIAL.—Dr. E. Mann (*Tonind. Ztg.*, **40**, 102, 1916). The writer considers this to be the best material for floors of houses, as it is not dearer than boards, is jointless and easily kept clean. The plaster may be coloured, and it is not necessary, as is so often believed, to cover it with linoleum. P.W.T.

FURNACE SLAG AS AN AGGREGATE OF CONCRETE.—H. Haesler (*Tonind. Ztg.*, **40**, 134, 1916). In spite of good results obtained with slag, its hardness and good appearance, this material is not usually in favour. It is feared that the pieces may become disintegrated, but tests made in 1914, show that being embedded keeps it from exposure to air. Its crushing strength is greater than that of other aggregates. Tests with mixtures of 1 part cement, 2 parts sand, 3 broken slag with 6 water, gave an average crushing strength of 318 kg/cu.cm. Using gravel, limestone, broken bricks instead of slag (proportions remaining the same), the figures were 272, 281, and only 151 respectively. P.W.T.

LIME ASH.—H. Eckert (*Tonind. Ztg.*, **40**, 139, 1916). The formation of ash is, as a rule, considered a necessary evil, and only a few producers of lime give due attention to lessening the quantity of ash. Careful attention should be given to the moisture content of the raw stone, as it is known that completely dry stone requires more fuel than stone containing a certain quantity of moisture—the steam facilitating the escape of carbonic acid. But too much moisture is to be guarded against, especially with compact limestone, as the steam escapes too rapidly, breaking the stone into pieces. More attention should be given to firing, fuel, influence of weather, etc. At certain times there is always a good demand for lime ash, and the price is always too low. Less ash would mean a better price and larger output of lime. P.W.T.

CEMENT CASES FOR COFFINS.—A. Offenbach (*Tonind. Ztg.*, **40**, 146, 1916). A description of these articles, giving the method of moulding and ingredients of the cement. They have been made in the U.S.A. for some years. P.W.T.

XII.—ANALYTICAL PROCESSES.

ULTIMATE CHEMICAL ANALYSIS OF REFRACTORIES.—(*Brick, Pot. Tr. J.*, **26**, 19, 1918). Tentative methods proposed by American Society for Testing Materials. See TRANS., **16**, Abs. 127, 1917.

DETERMINATION OF ZIRCONIUM IN ORES AND ALLOYS.—J. D. Ferguson (*Chem. Zentralblatt*, 6th series, II., 545, 1919. Abstract Eng. Mining *J.*, **106**, 793, 1918).

QUICKLIME CONTENT OF MILK OF LIME.—G. Lenart (*Chem. Zentralblatt*, 6th Series, II., 560, 1919). For determination of the quicklime content, etc., the author recommends the use of a rough pycnometer (glass or metal cylinder of 500—1000 C.C. content), the corresponding concentration being read off from a table given. The table is worked out for 20°C., but at 30°C. the specific gravity is about 0·002, and at 40°C. about 0·005, smaller than at 20°C.

DETERMINATION OF THE VOLATILE MATTER IN OXIDES OF LEAD.—O. Andersen (*J. Amer. Cer. Soc.*, **2**, 782, 1919). Relates particularly to ascertaining exactly the amount of PbO in litharge or red lead used in preparing glass batches.

The ignition is done in a platinum crucible—preferably of small diameter so as to diminish loss by volatilization of lead oxide. To prevent any attack on the platinum the sample of lead oxide is mixed with sand or ground quartz—1 part by weight to about 3 parts of PbO. The formation of a low melting compound and eutectics in such a mixture causes melting to take place about 100°C. below the melting point of pure PbO (about 880°), resulting in a silicate melt which does not appreciably attack the platinum. The exact procedure is described, and some results are given.

RAPID METHOD OF DETERMINING MAGNESIUM.—F. W. Bruckmiller (*The Chemist-Analyst, J. T. Baker Chemical Co.*, p. 7, Jan. 1919). Remove silica and calcium in usual manner, evaporate to dryness to remove excess ammonium salts, treat with water and filter. Make filtrate (at least 100 c.c.) alkaline with NH_4OH, cool in ice water, then add excess of microcosmic salt solution. Stir well for some time (until all Mg down) and then add 10c.c. NH_4OH, again stirring well. Filter and wash with 3 per cent. ammonia water several times by decantation. Contents of filter paper washed back into beaker by hot water, and whole boiled until ammonia driven off. Methyl orange indicator is added and solution titrated with standard solution of HCl (0·10N, 0·05N, or 0·02N, 1c·c.=0·00120g.Mg, 0·00060gMg, or 0·00025g.Mg respectively).

DETERMINATION OF BORIC OXIDE IN GLASS.—J. D. Cauwood and T. E. Wilson (*J. Soc. Glass Tech.*, **2**, 246, 1918). A note relating mainly to Sullivan and Taylor's modification of Wherry's method. From the results of investigations the authors conclude that the accuracy of the titration of boric oxide solutions is not affected by increasing the bulk of the solution to 300c.c. (instead of keeping down to 100c.c.), though it is advisable to keep the bulk down so far as is consistent with complete washing of precipitates.

For the determination of boric oxide in glass, Wherry's method is satisfactory for zinc and lead-free glasses, provided that filtrations and washings are carried out under suction. This method can also be employed for glasses containing small amounts of zinc (say of the order 3 per cent.), but it is advisable to use Sullivan and Taylor's modification of the method for all borosilicates containing zinc or lead.

XIII.—INSTITUTES, EDUCATIONAL, HISTORICAL.

CERAMICS AND MONUMENTAL ART.—C. Kornhas (*Tonind. Ztg.*, **42**, 505, 1918). An article with four illustrations.

PORCELAIN COLLECTION.—(*Tonwar. Ofen. Ztg.*, **42**, 27, 1918). A short notice of the sale by auction of the collection of a foreign private owner in February, including Meissen, Frankenthal, Ludswigburg, and Nymphenburg groups, etc.

VIENNA PORCELAIN MANUFACTURE.—(*Tonwar. Ofen. Ztg.*, **42**, 93, 1918). A short note with reference to this 200-year old manufacture.

SECOND ANNUAL REPORT OF THE DELEGACY FOR GLASS RESEARCH.—(*J. Soc. Glass Tech.*, **2**, 155, 1918). Relates to work done at Sheffield University, including the Department of Glass Technology.

NATIONAL MANUFACTURE AT SÈVRES, ETC.—O. Boudouard (*Cer.*, **21**, 77, 1918). A brief historical sketch of the origin and progress of the manufacture of porcelain in France, especially at Sèvres, and of Ceramic instruction in France.

INDUSTRIAL POTTERY MUSEUM.—(*Pot. Gaz.*, **43**, 788, 1918). An account of a visit by members of the Art Section (of Ceramic Society) to the industrial collection of pottery belonging to Wengers, Ltd., at Etruria.

ORIENTAL AND EUROPEAN PORCELAIN, ETC.—(*Pot. Gaz.*, **43**, 865, 1918). An account of a visit by members of the Art Section to view the Collier Bequest in Manchester Art Gallery.

SOLON LIBRARY.—(*Pot. Gaz.*, **43**, 943, 1918). An account of the formal opening ceremony, with address by Sir H. Cunynghame.

TRAINING AND WORK OF THE CHEMICAL ENGINEER.—(*Trans. Faraday Soc.*, **13**, 61, 1918). A general discussion.

THE EVOLUTION OF BRICKS AND TILES IN ANTIQUITY—NEUMANN (*Tonind. Ztg.*, **40**, 111, 112, 117, 118, 121, 122, 1916). Three articles on the history, development, shape, use and size of bricks, and of roofing tiles in particular—chiefly Greek, Etruscan and Roman. With illustrations.

P.W.T.

Abstracts.

I.—RAW MATERIALS.

DIATOMACEOUS OR INFUSORIAL EARTH.—W. C. Phalen (*Chemical and Metallurgical Engineering*, **21**, 981, 1920). Diatomaceous Earth is composed of the siliceous remains of minute aquatic plants known as diatoms which have to be identified chiefly by aid of the microscope. For the most part, the organic matter has long since disappeared from the deposits.

These low forms of life, which exist under such varying conditions of depth, pressure and temperature as are found, for example, in the depths of the Atlantic and the warm springs of Yellowstone National Park, secrete silica in much the same way as molluscs secrete lime. Most of the known beds belong to the Tertiary epoch.

In chemical composition, diatomaceous earth is a hydrous silica or opal, but as a rule it contains many earthy impurities. In addition to other distinguishing characteristics, it does not effervesce when touched with hydrochloric acid.

Analysis of Diatomaceous Earths.

Locality.	N.H.	N.J.	Md.	N.H.	California.			
SiO_2 ..	80·53	80·66	81·53	75·68	65·62	86·92	72·50	86·89
Al_2O_3 ..	5·89	3·84	3·43	9·88	—	4·27	11·71	2·32
Fe_2O_3 ..	1·03	—	3·34	2·92	—	—	2·35	1·28
CaO ..	0·35	0·58	2·61	0·29	—	1·60	0·32	0·43
MgO ..	—	—	—	0·69	—	trace	0·83	trace
K_2O ..	—	—	1·16	0·02	—	2·48	1·88	3·58
Na_2O ..	—	—	1·43	0·08	—	—	—	—
H_2O ..	12·03*	14·01*	6·04*	9·21†	11·00	5·13	9·54	4·89
	99·83	99·09	99·54	98·77		100·40	99·13	99·3

*Water and organic matter.
†Nitrogenous matter and moisture.

Uses:—The chief use of diatomaceous earth is as a cleanser and polisher, in the form of powder or mixed with soap. It is a most effective non-conductor of heat, and has been used alone or with various compounds in coverings for boilers, steam pipes, furnaces and stoves, and in the manufacture of fire-proof cements.

It has great absorbent qualities (Sp. Gr. 0·33) which make it suitable for water filters. Boiled with shellac, it is used in the manufacture of records for talking machines.

In Europe, where it is more extensively employed than in the U.S., it has been used to convert liquid manures into convenient fertilisers by absorbtion. It has also been used in the manufacture of tile glazing, water-glass, cement, artificial stone, aniline and alizarine colours, paper filling, sealing wax, fireworks, hard rubber objects, matches, papier maché, as a container for liquid bromine and for other minor purposes. It is readily cut and shaped, and has been used in the construction of buildings in California.

Preparation:—Roasting is first resorted to, to expel as much water and organic matter as possible. It is then heated in a furnace to a moderately high temperature, care being taken not to destroy its porosity by overheating. Afterwards, it is finely ground between rollers, sifted and sacked. For certain purposes, it is only necessary to give it a prolonged drying at a high temperature prior to grinding and sifting.

In the dry atmosphere of S. California for instance, forty to fifty days' exposure reduces the amount of water in the material to approx. 5%. After air-drying, some of the material is sawn into bricks, and dried in kilns.

These bricks are used for insulating purposes. The rest of the material is finely powdered to be used for filtering. Some of the California material contains 5% of alumina which acts as a binder. This material is adapted to use for interior fire-proof walls and contains about 85% of silica. One of the deposits near Lompoc comprises extensive beds of soft white earth in a very pure state. When dried the material is utilized in making brick, tile and other refractory materials.

Diatomaceous earth is found very widely distributed throughout the U.S., from New England to California, and from Washington to New Mexico.

DIATOMACEOUS OR INFUSORIAL SILICA INDUSTRY. A. Bigot (*Cer.* **23**, 79—82, 1920). Diatoms consist of (1) a mineral substance forming the shell, *i.e.*, a hydrated silica; (2) Organic matter constituting the living cell. This diatomaceous matter has a brown, spongy appearance resembling turf and loses 85% water on drying. After roasting, its weight decreases by 33%. The residual powder has a pinkish colour and contains:—

Silica	92·60
Alumina	6·22
Oxide of Iron	1·33
Calcic-magnesia	0·85

and is in the form of very light flakes. A plastic body formed of the calcined silica of Stavanger (Norway) absorbs 120 parts of water to 1 of silica; a very fine plastic clay only absorbs 25 to 30 times its weight. This fossil silica also has the property of secreting air and gases in its pores. After roasting to 600° or 700° the organic and hydrous matter disappears, but neither the appearance nor the volume changes, and its capacity of absorbing gases and liquids is increased. Above 700° and especially round 1000° the silica contracts and becomes less porous.

Analysis.

	Lunaburg (Hanover)		Auxillac Cantal		Mostaganem	Le Sig		Le Sig	
	Crude	Roasted	Crude	Roasted	Crude	Crude	R.	C.	R.
Water of Combination ..	5·26	—	3·50	—	—	—	—	—	—
Organic Matter ..	8·43	—	3·00	—	5·70	6·40	—	5·20	—
Silica	81·25	94·15	88·90	94·60	90·00	74·00	84.60	86·50	94·00
Alumina	3·19	—	2·65	2·67	—	1·99	—	1·35	—
Oxide of Iron ..	1·34	—	1·50	0·66	—	1·06	—	0·50	—
Oxide of Titanium ..	0·15	—	0·26	—	—	—	—	—	—
Lime	0·18	—	0·20	0·35	—	6·61	—	2·95	—
Magnesia	0·20	—	0·15		—	1·58	—	0·75	—
Alkalis	—	—	—	0·35	—	2·16	—	0·40	—
Carbonic Oxide ..	—	—	—	—	—	6·20	—	2·70	—

The silicas possess catalytic properties. They transform air into ozone; in contact with hydrochloric acid, the ozone combines with the hydrogen of the acid, the chlorine being released. It is this property of condensing the oxygen of the air which accounts for the destruction of the tissue of sacks containing silica.

A study of the conductivity of silica shows that a silica with apparent density 0·190 is a ten times more powerful insulator than a silica or fireclay brick, or ordinary building brick with density 1·80. The lower the apparent density, the greater its non-conducting power, both of heat and of sound. At a temperature of 500°

Silica	absorbs ..	25 calories.
Mixture of Silica ..	,, ..	62·5 ,,
Refractory substances	,, ..	225 ,,

The property of retaining partially ozonised air has led to the use of the silicas industrially as oxidising, disinfecting, and purifying agents, for clarification of old wines, brandies, ciders, beers, etc., and decolourising oils, essences, glues, etc.

In the construction of furnaces, a series of experiments proved that with a layer of sand 0·25 m. thick in the vault a temperature of 1,320° was attained in 78 hours, whilst with a thickness of 0·15 m. of powdered silica only 28 hours were required.

HIGH GRADE SILICA FOR LOS ANGELES.—(*Chem. and Met., Eng.*, **23,** 211, 1920). A new plant of the Western Silica Co., has been opened at Los Angeles. The initial output, which will soon be increased, was 35 tons of washed silica per day. The plant is intended to develop the large deposits of high grade silica in Antelope Valley. From some of these deposits the silica is over 99% pure.

PHILIPPINE INDUSTRIAL MATERIAL.—Dr. A. J. Cox (*Chem. and Met., Eng.*, **23,** 137—144, 1920). A general survey of the industrial resources of the Philippines. Raw materials for the manufacture of Portland cement, in some cases near undeveloped coal fields are abundant. Mineral resources include fireclay, sulphur and stone.

PIPE CLAY, POTTERY CLAY, KAOLIN, ETC., IN NEW SOUTH WALES (Annual Report, Department of Mines, N.S.W., 1919). The following is a survey of the quantities of material raised in the State of New South Wales in the year 1919.

The Lithgow Valley Colliery Co., Ltd., produced 885 tons of pipeclay, which was made up into pipes and sanitary ware.

The Port Stephens Fire Brick Company Ltd., raised 950 tons of fireclay, valued at £950.

Parish of Narrangarrie, County of Argyle, 400 tons fireclay.

Boxer's Creek, Goulburn Division, 220 tons pottery clay.

Cowra Division—500 tons Kaolin, valued at £1,000. It is proposed to extend the drying sheds and instal an engine and grinding mills.

Murrumburrah Division—373 tons Kaolin, valued at £485.

Parkes Division—100 tons Kaolin, valued at £300.

Gulgong Division—200 tons Kaolin, 126 tons sold at £121. During the year 130 feet were driven. Deposit averages about 30 feet in thickness, with an overburden of about 50 feet. Also 150 tons Kaolin in same locality, valued at £112. Other areas are being prospected.

Gunning Division—300 tons Kaolin, value £600. There is a large quantity of Kaolin in sight on the area.

Goulburn Division—68 tons Kaolin, value £125, at Shaws Creek.

Sydney Division—637 tons, value £500, shipped to Potteries from Brookvale.

INVESTIGATIONS ON ZIRCONIUM.—J. W. Marden and M. N. Rich (*J. Ind. and Eng. Chem.*, **12,** 651—6, 1920). Account of various chemical processes for the preparation of zirconium oxide, and zirconium metal. The article is a summary of a report on the subject issued by the U.S. Bureau of Mines.

THE POSITION OF CLAY PRODUCTS.—K. T. Stull (U.S. Bureau of Mines) (*Brick*, 54,782—4, 1919). A paper dealing with the position in the American industry. An unsuccessful attempt was made during the war to develop a pottery mixture of all American materials. English clays are still essential for tableware.

SUBSTITUTES FOR BOHEMIAN RAW MATERIALS IN THE GERMAN PORCELAIN INDUSTRY.—*Sprech.*, **52,** 13—14, 1919). With proper treatment suitable materials can be found in sufficient quantities to replace Zettlitz kaolin and brown coal from Bohemia.

EXAMINATION OF CLAYS FOR DUTCH TILES.—G. Heinstein (*Sprech.* **52,** 19—20, 23—24, 1919). An account of experiments carried out with various clays, the results of which are tabulated.

AMORPHOUS SILICA OF SOUTHERN ILLINOIS.—E. A. Holbrook (*Engineering and Mining J.*, **103**, 1136, 1917). The principal silica deposits occur in Union and Alexander Counties, in the South West of Illinois. The deposits of amorphous silica occur in Cherts of Devonian age, and among the latter is obtained the hard-chert or novaculite gravel quarried for road-making material. This road-making material is derived from alternating hard and soft layers in the cherts, the softer layers acting as a binding material. Other layers of the cherts consist of soft pure white amorphous silica (up to 6-ft. or more thick) with intervening darker beds of about the same material, usually red; only the pure white material is ground to an impalpable powder for use in the arts and industries, after being got by mining. The white amorphous silica contains usually 95 to 97 per cent. SiO_2. According to Bulletin 18 of the Illinois State Geol. Survey (p. 37) the finely divided silica from southern Illinois is really a finely divided quartz, the bulk of the material consisting of particles less than 0·01 mm. (or 0·0004 inch) in diameter. The fine wet-ground silica is divided into three grades, but all these are so fine that screening or touch tests are useless to determine fineness, although an expert can readily determine comparative fineness by tasting.

The ground silica is used as wood filler, as a reinforcer in lead and zinc paints and as an inert material in mixed paints and varnishes where it replaces whiting and barytes. It is also used largely in scouring soaps, in the manufacture of high-grade metal polishes, both liquid and paste, and in many cases it takes the place of pumice stone and rottenstone in the metal and wood-finishing trades for rubbing and polishing purposes. The best billiard-cue chalks are made from the ground-silica products.

GRAPHITE.—L. W. Brooks (*Mining and Sc. Press.*, **115**, 391, 1917). A comprehensive review of its technology, etc. Graphite, plumbago, and blacklead are practically synonymous, referring to the same chemical substance, but they are used in special applications, as in graphite lubricants and paint, plumbago crucibles and foundry-facings, blacklead stove-polish, lead pencils. Other uses of graphite are for powder, glazing, electro-typing, steam-packing, etc.

Amorphous graphite is always associated with other earthy materials, Crystalline graphite shows great variations also, because of the distortion of its crystals during the process of formation. Crystalline graphite occurs massive, as in Ceylon, or with its particles disseminated through a containing rock, as in American deposits. Crystalline graphite comes from Ceylon, Korea, Madagascar, New York, and Alabama. Amorphous graphite comes from Mexico, Rhode Island, and Canada. Graphite is widely distributed, but apart from the localities mentioned, with Germany, Austria, and Italy in Europe, it is rarely available as a source of supply. The percentage of carbon ranges from 40 per cent. in low grades of German and Austrian blacklead to 98 per cent. in fine grades of Ceylon graphite.

The manufacture of lead pencils and that of crucibles (including plumbago crucibles) is described in some detail. The chief advantage of the plumbago in a crucible arises from its capacity to absorb and transmit heat, but it is also infusible at temperatures below that of the electric arc, and its electrical conductivity is comparatively high. A plumbago crucible can withstand sudden changes of temperature, for it can be heated to whiteness and thrown into cold water without any apparent damage.

The peculiar softness of graphite adapts it for various uses. The laminated or flake form of graphite as prepared for market is irregularly circular in shape, having an average diameter of 1/40-inch. The thickness of these flakes varies from 1/500-inch to less than 1/4000-inch.

CLAY RESOURCES OF SOUTHERN SASKATCHEWAN.—N. B. Davis (*Canada Dept. of Mines*, 1918). A report on the occurrence of various fireclays, refractory and semi-refractory. In one locality are clays classed as ball clays, containing about 58 per cent. silica and 26 per cent. alumina, but with other constituents comparing well with English, Florida, and

New Jersey ball clays.

CLASSIFICATION OF CLAYS ON A CERAMIC BASIS.—A. S. Watts (*J. Amer. Cer. Soc.*, **3**, 247, 1920). A ceramic classification of clays is proposed, to be based on not more than five properties, viz., colour (when fired), shrinkage, bonding strength, vitrification, and fusion. As regards colour, white, cream, buff, and tan are sufficiently distinct to meet most cases without much risk of confusion; red, brown, etc., could be used in exceptional cases. Shrinkage should be stated as drying and total shrinkage, that is, decrease in length from the plastic state to the bone dry state and to some definite fired state often at cone 10, respectively. Both shrinkages should be expressed as percentages of the original length. Bonding strength should be determined with a mixture of equal parts by weight of clay and standard (Ottawa) sand, the modulus of rupture being best determined by the transverse test. Vitrification and fusion data are to be expressed in cones

The entire classification may be summarised as follows:—Colour: White, Cream, Buff, Tan.

	Low	Medium Low	Medium	Medium High	High
Shrinkage—drying	0-3%	3-6%	6-9%	9-12%	Above 12%
Shrinkage total, cone 10	0-4%	4-8%	8-12%	12-16%	Above 16%
Bonding strength, modulus of rupture, 50 per cent. Clay and 50 per cent. standard sand ..	0-100-lb.	100 to 200-lb.	200 to 400-lb.	400 to 800-lb.	Above 800-lb.
Vitrification expressed in Cones ..	Below Cone 5	Cone 5 to 15	Cone 15 to 25	Cone 25 to 30	Above Cone 30
Fusion expressed in Cones	Below Cone 5	Cone 5 to 15	Cone 15 to 25	Cone 25 to 30	Above Cone 30

It may be mentioned that the drying shrinkage is generally 3 to 5 per cent. for primary kaolins, flint fireclays and sandy clays, between 5 and 8 per cent. for plastic fireclays and secondary white clays, 8 to 12 and exceptionally as much as 15 per cent. for ball clays and very plastic shales. After firing to cone 10 the primary kaolins generally show 9 to 12 per cent. total shinkage, flint fireclays 6 to 10 per cent., secondary white clays 10 to 14 per cent., and ball clays 16 to 18 per cent.

STORING AND HANDLING OF RAW CLAYS.—T. W. Garve (*J. Amer. Cer. Soc.*, **3**, 266, 1920). A general discussion, including references to belt conveyors, returning cars, etc.

WASHING COAL, ETC.—C. Burnett (*Pat. J.*, No. 1616, 1920). Pat. No. 134,596, Nov. 1, 1918. Coal or other material, particularly slack or fine coal, is washed first in a trough or conveyer and afterwards by water forced through or into it. The plant used is illustrated.

POTASSIUM CHLORIDE.—E. Bury, O. Ollander, T. Smith, and F. Bainbridge (*Pat. J.*, No. 1616, 1920). Pat. No. 134,665, Dec. 3, 1918. Relates to the recovery of potassium chloride after adding calcium chloride to molten blast furnace slag.

SEPARATING DUST FROM COAL, ETC.—Maschinenbau-Anstalt Humboldt (*Pat. J.*, No. 1618, 1920). Pat. No. 135,204, Nov. 13, 1919. Relates to an apparatus for removing dust from fine coal or the like, comprising a centrifugal wheel adapted to throw the material to be treated against an impact surface in such a manner that the coal and dust fall in a spread-out condition through an air blast from a fan, the dust being carried upwards over a wall into a chamber, while the coal collects on the bottom of the sorting chamber.

POTASSIUM CHLORIDE, ETC.—E. E. Dutt and P.C. Dutt (*Pat. J.*, No. 1618, 1920). Pat. No. 135,246, Oct. 18, 1918. Potassium chloride is obtained by treating at a red heat a mixture of potassium fluoride, silica, and carbon, with a stream of hydrochloric acid gas in a rotary furnace (such as that described in Specification 124,554.) The liberated silicon tetrafluoride is used to react upon felspar, which is placed in the second compartment of the furnace, the reaction being that described in Specification 133,474.

MINING CLAY, ETC.—Osmosis Co. and J. S. Highfield (*Pat. J.*, No. 1618, 1920). Pat. No. 135,277, Nov. 19, 1918. In mining clay, etc., for pottery, etc., an alkaline electrolyte, such as caustic soda or carbonate or silicate of soda is added to the water used in mining the clay, or in the settling-pit in the mine, in order to obtain a thinner suspension for a given quantity of clay and so facilitate pumping. The quantity of caustic soda required is preferably 1/20 to 1/5 per cent. of the weight of clay carried in suspension.

POTASSIUM SULPHATE.—E. E. Dutt and P. C. Dutt (*Pat. J.*, No. 1619, 1920). Pat. No. 135,545, Oct. 18, 1918. Potassium fluoride and silica are heated to 800°C. in one of the revolving furnaces described in Specification 124,554, whilst sulphur dioxide and steam are passed in. Silicon tetrafluoride is evolved, leaving a residue from which potassium sulphate is obtained by lixiviation. The silicon tetrafluoride is introduced, along with water vapour, into the second revolving furnace, where they react with a potash-bearing silicate rock such as felspar in the manner described in Specification 133,474 to produce potassium fluoride.

POTASSIUM NITRATE.—Chemical Construction Co. (*Pat. J.*, No. 1619, 1920). Pat. No. 135,713, Feb. 20, 1919. Potassium is recovered as the nitrate from the waste gases of cement kilns and the like by bringing the gases into intimate contact with a solution of a metal nitrate, preferably sodium nitrate. The potash and the carbon dioxide in the gases interact with the sodium nitrate to form potassium nitrate and sodium carbonate, hydrosilicates being also produced from the silicates present in the gases. The hydrosilicates are rendered insoluble by heating the solution, leaving the potassium nitrate and sodium carbonate to be separated by crystallization.

POTASSIUM SALTS, GAS-WASHERS.—Chemical Construction Co. (*Pat. J.*, No. 1619, 1920). Pat. No. 135,720, Feb. 24, 1919. Hot gases such as cement-kiln gases, which contain potassium compounds and insoluble matter, are washed first in an apparatus which collects the insoluble matter and part of the potassium compounds in a liquid, and then in another apparatus in which the remaining potassium compounds are collected as a clear solution. The slurry produced in the first washer is treated for recovering the potassium salts. The second washer may be supplied with an acid, such as sulphuric, nitric, hydrochloric, or boric acid, to obtain the corresponding salts.

SILICA.—W. A. Patrick (*Pat. J.* No. 1621, 1920). Pat. No. 136,543, Dec. 6, 1919. A silica gel, suitable for absorbing gases and capable of retaining its properties up to 700°C., is obtained by mixing equal volumes of an acid, such as hydrochloric acid, and sodium silicate solution of such strength that all the silica is liberated, and efficiently stirring the mixture so that immediate separation of silica is prevented. The temperature of the solutions may be 35—80°C., preferably 45—50°C. When the gel has formed, it is broken up, washed, and slowly dried. The drying is effected in a current of air at 75—120°C. followed by increasing the temperature to 300—400°C., or by drying at the lower range of temperature in a vacuum.

II.—THE PHYSICAL, CHEMICAL AND OTHER PROPERTIES OF RAW AND FINISHED PRODUCTS. TESTING.

THE INTRODUCTION OF PETROGRAPHY IN THE STUDY OF THE RAW MATERIALS AND MANUFACTURED PRODUCTS IN CERAMIC INDUSTRY.—L. Bertrand (*Cer.* **23,** 50—54, 1920). The writer emphasises the necessity of petrographic investigation in conjunction with chemical analysis.

A veined quartz and a quartzose sandstone for example, the chemical compositions of which are identical, give entirely different results in practice, when used in making silica bricks. Mechanical and thermal tests carried out concurrently by M. Bodin, entirely confirmed the results of petrographic investigation conducted by the author.

Similar research is now being conducted with clays, and although this is far from complete, it may be stated already that various axioms at present accepted in Ceramics will not stand microscopic investigation.

It is customary in Ceramics to attribute the alkalis in clays to the presence of mica scales. But in the case of many samples of clays coming from the immediate vicinity of rock massifs from which they derive their mica, microscopic investigation of thin layers rarely shows an appreciable proportion of particles of mica, whilst chemical analysis indicates a proportion of 2% or more of alkalis.

The microscope demonstrates therefore, that the current method of calculating the proportion of mica present in a clay from the amount of alkalis shown by chemical analysis, must be abandoned, since this mica is often non-existant.

In the chemical analysis of clay, it is very important to separate the free silica from the combined silica which enters into the composition of the clay base. The free silica is generally attributed almost exclusively to the fine grains of quartz. Certain clays however, which, by analysis, are rich in free silica, show only a minute proportion of quartz grains under the microscope. Chemical research demonstrated the presence of hydrated silica—in some cases as much as 18%—soluble in alkalis, which therefore, did not polarise under the microscope. It is also probable that traces of alumina exist in the same state in certain clays.

Under the polarising microscope, the clay base itself shows a variety of structures, sometimes exhibiting well-defined particles of kaolinite, or the molecular grouping in the cryptocrystalline state of the halloysite type. These variations obviously have important effects on the plasticity, fusibility, etc., of the clays.

The microscopic method has also led to investigations as to the precise reasons why one clay is lean and the other fat. There is no strict relationship between the leanness or richness of a clay and the percentage of SiO_2 and Al_2O_3 which it contains. Certain clays rich in silica are enormously fat, because the free silica is in a hydrated state. Inversely, clays rich in kaolinite scales, are less plastic than clays with the same proportion of alumina in a halloysite base; they are, so to speak, enormously lean.

ELECTRO-OSMOTIC PURIFICATION OF CLAYS.—(*Cer.* **23,** 58, 1920). A review of the work done in this branch of research by Graham, Bliss, Count Schwerin and Dr. Ormandy. The article closes by quoting in full A. V. Bleininger's concluding remarks on this subject in Trans. Amer. Cer. Soc., Vol. XV., 1913, pages 338—343.

A RAPID METHOD OF DETERMINING THE RELATIVE POROSITY OF CERAMIC PRODUCTS.—Prof. L. Bertrand and Ch. Boulanger (*Cer.*, **23,** 77—79, 1920. It is generally considered sufficient to determine the co-efficient of absorption of water, *i.e.*, the weight of water absorbed by a given weight of the substance. But it is important to notice that this

co-efficient of absoption is not strictly proportional to the relative porosity.

If V represents the exterior volume of a ceramic product, and v the volume of the pores, its relative porosity may be expressed by

$$\frac{v}{V}$$

Further, if D represents the apparent density of the substance, and W its weight,

$$W = V \times D$$

and if the water, in which it is immersed, is not at 4°, and has a density represented by d, the weight (w) of water absorbed is $w = v \times d$.

Therefore, whilst the co-efficient of absorption is $\frac{w}{W}$, the relation porosity is $\frac{v}{V} = \frac{w}{W} \times \frac{d}{D}$.

Even if the water is at its maximum density, or if the necessary corrections are made to allow for the actual density of the water used, we get simply that—the expression of porosity is the product of the co-efficient of absorption with the apparent density of the substance. But as this latter may be variable, it follows that there is no direct relation between the relative porosity and the coefficient of absorption.

To arrive directly at the coefficient of relative porosity, three weighings only will suffice, viz:—

W_1—weight of ceramic substance *dry*.

W_2—weight of substance saturated with water or any other liquid, of density d.

W_3—weight of substance saturated and suspended, entirely submerged, *in the same liquid*.

Then evidently

$W_2 = W_1 + vd$, whence $vd = W_2 - W_1$

$W_3 = W_2 - Vd$, ,, $Vd = W_2 - W_3$

therefore, coefficient of porosity $\frac{v}{V} = \frac{W_2 - W_1}{W_2 - W_3}$

Here it is not necessary to know the density of the liquid employed. To shorten the period of immersion necessary to allow the substance to become thoroughly saturated, other liquids with a much weaker capillary tension than distilled water may be used, such as tetrachloride of carbon.

MICROSCOPIC EXAMINATION OF CLAYS.—R. E. Somers (*Journ. Washington Acad. of Sci.*, No. 5, 1919). Most of the clays referred to in this report were examined microscopically, in order to determine the minerals contained in them, and in addition thin sections of some of the burned samples were studied to obtain some idea of the changes that took place in burning.

Identification and character of Minerals.

Quartz. In medium or coarse grains can be readily discriminated by means of its index of refraction, low interference colours, and lack of cleavage. No other minerals in clay resemble it under these conditions. In small grains, however, it greatly resembles kaolinite, and its determination has to depend upon its more angular shape and its more rapid extinction, or "quicker wink," Such grains are generally too small to make use of the difference in optical character. Quartz was particularly abundant in residual clays.

Kaolinite. Distinguished by its orthodox character when of larger size, combined with its flaky nature and very often its tendency to combine in fan—or worm—shaped bunches. Low index of refraction and low birefringence separates it from the other micaceous minerals. When fine it can merely be noted as minute, transparent plates, of an index of refraction close to the balsam, and very low interference colour. Kaolinite occurs as single scales or plates, sometimes in bunches of fan-shaped character, and as vermiculites.

Hydromica. A distinctly micaceous mineral, single and double refractions higher than kaolinite but not so high as muscovite and sericite. The degree of these refractions varies in different clays. It is therefore assumed that there is an isomorphous gradation between sericite and kaolinite with a gradual loss of potash and addition of water. Hydromica represents a transition stage of weathering towards kaolinite as a final product. The fan of the hydromica is similar to that of the kaolinite, but it may occur in large grains.

Descriptions of the microscopic examination of clays that have appeared from time to time, make frequent reference to kaolinite, but the presence of mica is less often commented on; yet, judging from the nature of the clays described in this report, it seems to be quite abundant.

In 1906, Vogt concluded that china clay consisted of kaolinite, muscovite and quartz, basing his conclusions on the chemical composition.

Later, Hickling, after studying the china clay of Cornwall, states that in the finest washed clays, kaolinite, mica, quartz and tourmaline are present, but that the first two make up 90 per cent. of the mass. The relative amounts of kaolinite and muscovite are difficult to estimate. He differentiates the mica into two classes—primary and secondary mica derived from felspar. He refers to the kaolinite as occurring as irregular hexagonal prisms, with rough faces, which show strong transverse striations corresponding to the basal cleavage. Isolated plates or very short prisms may occur, and then even with convergent polarised light, it is not easy to judge the amount of birefringence under such circumstances, and consequently, to decide to which mineral a given fragment belongs. Both kinds show the same irregular form and the same evidence of corrosion on the edges. The low interference-tint and low index of refraction definitely distinguish these crystals from mica.

The identification of kaolinite rests on the following evidence:

(*a*) The index of birefringence is distinctly low, about that of quartz, but variable.

(*b*) The index of refraction is very near to 1·56.

(*c*) The prismatic crystals extinguish parallel to the basal plane.

(*d*) Basal flakes show a biaxial interference figure.

While Hickling refers to the mica as muscovite, he notes that it may be hydrated; he thinks that the muscovite changes directly to kaolinite in the clay, because: (1) He can find mica but no kaolinite in felspar or in granite. (2) There is no difference in form between mica and kaolinite. (3) He finds prisms which are mica at one end and kaolinite at the other. As showing a conversion in the direction of kaolinite, he quotes the observations of Johnstone, who found that on exposing muscovite to pure water, and water saturated with CO_2 for 12 months, it had changed to hydromuscovite.

Halloysite. Two of the clays contain material in plate-like grains, which are isotropic, and are probably halloysite.

Rutile. The presence of rutile is interesting, in view of the probable constant occurrence of titanium in high-grade clays. Practically every clay shows rutile in some amount, sometimes in grains or prisms, 0·015—0·020 mm. in diameter, when its colour and refractive properties distinguish it at once. More generally it is found as very minute grains (0·001—0·010 mm.) or needles, five or six times as long as they are wide, which are so clear cut that their refractions can be plainly seen. The interference colour is of the first order, but the particles are so small that the actual birefringence is thereby shown to be very high.

Rarer Minerals. Tourmaline is well marked by its pleochroism, and its frequent occurrence is notable. Epidote is occasionally seen as a slightly greenish mineral of moderate single and double refractions. Grains of both high refractive index and birefringence are common, though not in any abundance, and they prove to be zircon and titanite. A distinction between the two is quite possible by means of the higher interference colours of the titanite. Zircon is much the commoner.

Diaspore. This is easy to determine by its moderately high refractive index and double refraction, and its occurrence in irregular grains. It sometimes occurs in grains sufficiently large to be seen by the naked eye and may be mistaken for quartz, but it can be separated from it and clay by means of bromoform (sp. gr. 2·8) in which the diaspore (sp. gr. 3·4) sinks, while the associated minerals float.

With regard to the texture of these clays, relatively coarse grains average 0·100 mm. or more in size, medium grains 0·020—0·025 mm., and fine grains 0·010 mm. or less.

Minerals in the burned clay.

A number of the clays were moulded into one-inch cubes. These were all fired for 8 hours up to 950°C. One set was then refired for 8 hours to 1,150°C, and a second set for 10 hours to 1,300°C. They were then ground to thin sections and examined under the microscope.

Quartz grains usually stand out with much greater clearness in the burned than in the raw clay due to the fact that the hydrous aluminum silicates tend to mat or fuse together to a fine-grained ground mass which holds the quartz.

Hydromica on heating to 1,150°C either practically disappears, forming an isotropic mass, or else it loses the greater part of its interference colour. The only exception to this was where the hydromica grains were much larger than usual, in which case it was noticed that the central portion of the grains retained usually the original interference colour. This change on heating, would seem to suggest that the hydromica furnished some of the flux for the clay, and other things being equal, there may be a connection between the degree of densification at the temperature mentioned, and the quantity of hydromica present.

Kaolinite, when not fluxed, appears to retain its shape and at least a good part of its original interference colour. Tourmaline and probably epidote disappear even at 1,150°C., but the rutile, zircon and probably titanite seem to be unaffected even at 1300°C. The persistence of the rutile can be plainly seen even though the particles are very small. Sillimanite was noticed in a Florida white clay fired at 1,300°C. where the conditions happened to be just right for its development. That it was formed from the large flakes of kaolinite or low-grade hydromica was clearly indicated by one composite flake of the two minerals. The actual reason for its development is not evident, other clays carrying similar micaceous flakes, and burned at the same time, not showing the sillimanite in the burned product.

This development of sillimanite by burning and its possible abundance in porcelain is regarded as a feasible explanation of another feature noted. In some of the clays a double refraction is produced in the ground mass of the clay by burning at high temperatures. It is very probable that this is caused by particles too minute to be easily recognisable, and that the development of the interference colour may be due to the formation of sillimanite.

In the sections where sillimanite was actually determined, it is present in the form of slender crystals of fair size, and can easily be distinguished by its moderate relief, low interference, optical character, and cross fractures.

Table 2 gives in summarised form the features which a number of the thin sections show.

STONEWARE IN THE CHEMICAL INDUSTRY.—A. Granger (*Chem. Ind.*, **1**, 35T=243, 1918). A general survey of the subject, including analyses of stonewares and of stoneware clays, treatment of the clays, manufacture of various vessels, firing, glazing, and a brief consideration of the qualities requisite in stoneware.

SLAG ENCLOSURES.—W. Rosenhain (*Revue de Métallurgie*, **9**, 998, 1912). Refers to various enclosures of slag in steel—constitution, formation and origin, with methods proposed for their prevention, etc.

TABLE 1 (Abridged.)

COMPOSITION OF CLAYS.

Formation and Locality.	Quartz	Hydromica	Kaolinite	Rutile	Zircon	Tourmaline	Epidote	Titanite	Diaspore	Halloysite	Colloid Matter*
RESIDUAL CLAYS.											
From Granite:—											
English China Clay, washed ..	S	M	VA	—	—	—	—	—	—	—	—
From Cambrian Schist:—											
Mt. Holly Springs, Pa. ..	C	A	VA	C	—	S	—	—	—	—	—
Narvon, Pa., Diller pit ..	A	A	A	C	S	S	S	S	—	—	—
From Cambrian Clayey Sandstone:											
Scotia Centre, Pa.	S	A?	C?	S	S	S	—	—	—	—	—
From Cambrian Shale:											
Cold Spring, Va...	—	S	A	A	S	S	—	—	—	—	—
From Cambrian Limestone:											
Lutesville, Mo., No. 2 ..	C	C	A	A	—	S	S	—	—	—	—
From Oriskany Shales, Limestones and Sandstones:											
Kunkletown, Pa. Clay with Quartzite	C	C	A	A	—	S	—	—	—	—	—
Saylorsburg, Pa. Crude, No. 1	A	A	A	A	—	S	—	—	—	—	—
,, ,, ,, No. 2	C	A	A	A	—	—	S	—	—	—	—
MISCELLANEOUS RESIDUAL CLAYS:											
Bauxite, Ark. banded clay under bauxite	—	S	VA	A	—	—	S	S	—	—	—
Beatty, Nev. Bond Marks Dep.	—	—	S	S	—	—	—	—	—	VA	—
Antioch, Cal.	S	S	VA	S	—	S	—	—	—	—	M?
Fort Payne, Ala. Cochrane pit Siliceous Bauxite	S	C	—	A	S	S	—	—	—	—	A
Fort Payne, Ala. Cochrane pit Bauxite	—	S	M	A	S	—	—	—	—	—	VA
Byrum, Ala, white clay ..	—	A	S	S	—	S	—	—	—	—	—
,, ,, black clay ..	—	C	—	C	S	—	—	—	—	—	A
SEDIMENTARY CLAYS.											
Carboniferous:											
Cheltenham Clay, St. Louis dis. Mo.:											
Raw washed pot clay ..	C	A	A	S	—	—	—	—	—	—	—
Weathered pot clay ..	C	A	C	A	S	S	—	—	—	—	—
Fire-brick clay	C	A	S	S	—	—	—	S	—	—	—

[Continued on next page.

Table 1 (Abridged). Composition of Clays—*Continued*.

Formation and Locality.	Quartz	Hydromica	Kaolinite	Rutile	Zircon	Tourmaline	Epidote	Titanite	Diaspore	Halloysite	Colloid Matter*
Huron district, Indiana: ..											
Earthy white clay	—	A	A	S	—	—	—	—	—	C	—
Massive ,, ...	—	S	C	C	—	—	—	—	—	A	—
Flint Clay district, Central Missouri:											
White clay, Owensville ..	—	S	S	S	—	—	—	—	—	—	C
Red Clay ,, ..	—	—	S	C	—	—	—	—	—	—	C
Flint Clay, Hofflinn Mo. Cox pit	—	S	VA	A	S	S	—	—	S	—	—
Diaspore Clay, Rosebud, Mo. Brown pit	—	—	—	S	S	—	—	—	VA	—	C?
Lower Cretaceous:											
White Clay, Gordon, Ga. upper bed	C	C	A	S	—	—	—	—	—	—	M
Nodular Clay do. ..	S	—	S	S	S	—	—	—	—	—	VA
White Clay, S.W. of Trenton, S.Ca.	A	C	A	S	—	—	—	—	—	—	—
Upper Cretaceous:											
Rayflin, S.Ca...	A	S	A	S	S	—	S	—	—	—	—
Ripley:											
White Clay, Perry Ga. ..	S	S	S	C	S	—	—	S	—	—	A
Saggar Clay, Hollow Rock, Tenn.	C	A	C	C	—	S	—	—	—	—	—
Brown sandy clay, E. Paris, Currier pit	C	A	A	A	—	S	—	S	—	—	—
Porter's Creek:											
Wad Clay, Benton, Ky., Howard pit	C	A	A	A	—	—	S	—	—	—	—
Wilcox formation:											
Andersonville, Ga., white clay	—	C	A	S	—	—	—	—	—	—	—
Enid, Miss., No. 5 pit, Bramlett	C	VA	S	S	—	S	—	—	—	—	—
Holly Springs, Miss., Stoneware Clay	C	A	A	C	—	—	—	—	—	—	—
I.S.G.P. Clay, Whitlock, Tenn.	S	A	C	C	—	S	—	—	—	—	—
Crude, Edgar, Fla.	A	S	A	S	S	—	—	—	—	—	—
Washed ,, ...	S	A	A	S	S	—	—	—	—	—	—

* exceeding small grains not identifiable, apart from colloidal particles not visible under ordinary microscope.

S. Scarce; C. common; M. moderate amounts; A. abundant; V.A. very abundant.

TABLE 2 (Abridged).

FEATURES SHOWN BY THIN SECTIONS OF BURNED CLAY.

						1150° C		1300° C	
Locality	Texture	Quartz	Hydro-mica	Kaolin-ite	Rutile	Porosity per cent.	Appearance	Porosity per cent.	Appearance
Sagger clay (Tenn.)	Medium	C	A	A	A	—		9·1	Micaceous texture remains. Hydromica interference colour gone. Groundmass shows mostly kaolinite interference, a very little isotropic material.
White sedimentary clay, granular (Andersonville, Ga.)	Very fine	—	C	A	S	43·7	A fine granular aggregate about ½ isotropic and ½ kaolinite interference colour.	33·1	Similar except it is beginning to develop mottled patches of low interference colour.
Benton, Ky.	Medium to fine	C	A	A	A	—		24·5	Hydromica all gone. Quartz grains in mostly isotropic groundmass. A few low interference colours.
Enid, Miss.	Medium	C	VA	S	S	—		0·6	Very fine, dense, felty aggregate. Low interference. Possibly sillimanite.
Kaolin, Lutesville, Mo.	Medium	C	A	A	S	14·4	Fine texture, partly isotropic, partly Kaolinite interference.	0·8	Little different from 1150°
Crude Kaolin, Saylorsburg, Pa.	Medium to fine	C	C	A	A	31·2	Granular, slightly matted groundmass. Hydromica colour gone. Some isotropic material.	2·9	More isotropic material. Rutile persists.
White clay, washed, Florida	Medium to fine	S	A	A	S	38·0	Fine grained groundmass with much isotropic material, and rest small flakes of low interference colour.	36·1	Felty appearance, with more interference colours of low order. Some of the larger mica flakes changed to sillimanite.

S. Scarce; C. common; A. abundant; V.A. very abundant.

COAGULATION OF CLAYS AND THE RETARDING PROPERTIES OF HUMIC ACID.—Sven Odén (*Journ. Landwirtschaft*, **3**, 177, 1919).

It was first shown by W. Springs that coagulation is accompanied by two independent processes, namely flocculation—or the running together of individual particles to form large "aggregates"—and sedimentation. By the Stokes formula the size of particles can be calculated from their rate of sedimentation. This however, does not give the actual dimensions of the particle but the radius of a spherical particle corresponding to the given rate of sedimentation. To this the writer gives the name "equivalent radius." The equivalent radius of the secondary aggregates can also be measured with some degree of accuracy.

In suspensions of highly plastic, fine-grained clays, where the rate of sedimentation of the primary particles is very low, flocculation takes place fairly rapidly and ceases when the aggregates reach given dimensions. The writer differs from Freundlich, whose work leads one to conclude that the characteristic of non-reversible coagulation lies in the fact that flocculation may continue indefinitely, and that the particles, as it were, blend with each other, whereas the author's experiments with colloidal sulphur, clays, and suspensions of $BaSO_4$, CaC_2O_4, etc., showed the following characteristics of reversible coagulation:—

1. The particles retain their individual character in the coagulated mass, and merely adhere to each other.
2. The secondary aggregates grow only to a very definite size.
3. Both speed and flocculation (aggregation) and size of the secondary aggregates depend upon the varying size, and the charge of the particles.

A fourth characteristic applies also to coarser suspensions and to certain clays.

4. By a mechanical agency, *e.g.*, a simple shaking, the secondary aggregates are again broken up into individual particles, without removing the coagulator. Flocculation again takes place at the same speed, as soon as the liquid comes to rest.

The stability of a suspension is in no way dependent on the Brownian movement. The addition of an electrolyte, which makes a sol particularly unstable, appears to have no effect on the Brownian movement of the particles. On the contrary, were there no Brownian movement, the particles would be less likely to come within the molecular attraction sphere of each other, thus favouring sedimentation of individual particles. At present very little is known of the nature of these capillary forces which exert sufficient attraction to unite the particles as soon as they are brought into sufficient proximity to each other by the Brownian movement. This attraction would continue to cause flocculation, were it not that other forces are active in preventing the particles from coming within each others molecular sphere. These forces are of an electric nature and are probably connected with the taking up of certain kinds of ions out of the dispersion medium.

The particles are also surrounded by a coating of water molecules. If this hydration is considerable, as is usually the case with clay particles, the particles are held together by this water covering, and the whole phenomenon is reversible since the particles can be shaken apart again. On the other hand, a thin covering of water molecules may be broken through by the shock of particles coming into contact, and the actual surfaces of the grains adhere. The process is then non-reversible in every way.

As already stated, the difference in potential, or "charge" of the particles, is probably due to the adsorption of certain ions. In pure water there are $6.2.10^9$ $H^{\cdot}$ ions and the same amount of OH' ions present in every litre, which is considerable, in comparison with the number of colloidal particles. But as pure water practically does not exist, impurities in ion form, such as $NH_4^{\cdot}$, HCO'_3, CO_3'' etc. being always present with the $H^{\cdot}$ & OH' ions, it is obvious that the colloidal particles have ample opportunity to unite with ions and thus receive a certain charge. As a whole, however, the particles remain neuter and are not influenced by any electro-static charge. This

implies that each particle is neutral at a certain distance and that difference in potential is only experienced in close proximity to the surface of the particle. The opinion is therefore held that the particle receives a certain charge by taking up certain ions either on its surface or in the water covering, and that this inner charge is compensated by an equal exterior charge within a given radius. This is briefly the theory of the double electric charge of colloidal particles. The ions forming the inner "layer" are to be considered as fixed to and moveable with the particles, the exterior ions, on the other hand, as mobile and clustering round the particles. This double "layer" of ions constitutes a dynamic and not a static equilibrium, they are, therefore, interchangeable with other ions in the dispersion medium. The inner charge, for instance, must not be considered as consisting of anions and the exterior of cations, though there may be a predominance of one or other of these types. The Freundlich formula: $\frac{X}{m} = \alpha c^{\beta}$ is here more or less applicable, where $\frac{X}{m}$ = the quantity of substance adsorbed per unit of weight, c = equilibrium concentration of the solution, α and β two variable, empirical constants.

The quantity of ions to be added to the dispersion medium in order to produce the necessary charge in the particles, varies considerably with different chemical substances. For clays it is generally sufficient to shake in pure water, but here again conditions vary considerably. Hall and Morrison showed experimentally that with kaolin ($Al_2Si_2O_7.2H_2O$) and natrolite ($Na_2Al_2Si_3O_{10}.2H_2O$) in sufficiently fine particles a stable suspension could easily be obtained in pure water, whilst experiments with Al_2O_3, quartz and allophane ($Al_2\ SiO_5.5H_2O$) were unsuccessful. Suspensions of the latter bodies, however, could be rendered stable by the addition of a small quantity of alkali, and the authors, therefore, rightly concluded that the traces of alkali, detached in hydrolysis, were responsible for rendering the kaolin and natrolite stable in suspension.

Experiments conducted by W. Pauli have proved the Freundlich theory that adsorption varies for the two types of ions. Adsorption varies also with the concentration of the ions, more of one type being adsorbed if the concentration is weak, whilst a greater proportion of the other is adsorbed in a stronger concentration.

If a salt (NaCl for instance) is added to a sol to such an extent that the particles are discharged to the critical potential (on account of the predominance of cation adsorption) and flocculation commences, and if, at this stage, another electrolyte (*e.g.*, HCl) is added, flocculation of the particles is suspended, since the adsorption constants α^1_c and β^1_c of HCl are much smaller than the corresponding constants α_c and β_c of the cation of NaCl, whilst the anion constants are the same in both, so that if sufficient HCl is added, the anion action is increased and the particles become charged again. To renew flocculation, a further addition of NaCl is then necessary. This process was actually observed with colloidal sulphur.

In clay materials α_{OH} is apparently very great, hence the particularly stablising action of ammonia and alkali.

The conductivity of a colloidal solution is composed partly of the conductivity of the dispersion medium and partly of that originating in the double electric charge (colloidal particle and ion clusters). No definite conclusion, however, can be arrived at by measuring the velocity of the particles, since the charge of the particles cannot be considered as an isolated electro-static charge (after the manner of the charge of fog particles in the atmosphere); electric motion can only take place by a simultaneous displacement of the two components—particle and ion cluster, when the resistance will work out quite differently from the hydrodynamic resistance obtained from the Stokes formula.

On reaching the electrodes, the particles are discharged, the double

charge is released, and flocculation is observed. In reversible systems, like clay, it is not necessary for the discharge to be complete in order to produce flocculation; it is sufficient to reduce the difference in potential between particles and liquid below a certain critical value. The smaller the residual charge of the particle, the larger the number uniting to form secondary aggregates, and the quicker the process of flocculation. When the residual charge is well below this critical value, thousands of primary particles unite in secondary aggregates, which begin to settle, and coagulation sets in.

The conclusion appears to be justified that the secondary aggregates, composed of particles and residual charge, can only grow to a certain size; when the internal charge of a secondary aggregate reaches a certain strength it has the effect of repulsing further particles, flocculation ceases and equilibrium is restored. It follows then that if the secondary aggregates must reach a certain size to produce coagulation, the particles in a fine-grain sol must undergo a much greater "discharge" than those of a coarser grain. Hence the varying coagulating value of an electrolyte according to the dispersity of the particles.

Since the secondary aggregates contain an inner residual charge, they are also surrounded by a compensating exterior cluster of ions of opposite valency, and these exterior ions are precipitated with the aggregates and are included in the coagulum.

In reversible coagulation therefore, the decomposition of the salt, so often observed in the non-reversible process, never takes place.

With regard to the coagulating value of an electrolyte, the writer recognises three grades. For every electrolyte there is a first value, below which no tendency to aggregation is observed. If this value is exceeded, however, resulting in a "discharge" to the point of critical potential, aggregation, accompanied by more rapid sedimentation sets in, without any outward form of coagulation making its appearance. In the case of clays, this first coagulating value depends much more upon the material than the degree of dispersity of the particles. For an *Ancylus* clay this first value for Na_2SO_4 was about 5 millimol. per litre, for a kaolin about 20 millimol. per litre.

If the concentration of the electrolyte is raised, the size of the secondary aggregate rapidly increases up to a certain point, corresponding to 2—5μ.

The concentration of the electrolyte is then about 50 millimol. per litre for kaolin. Sedimentation becomes noticeable after a few hours and a coagulation process is visible. This concentration of the electrolyte is the second coagulating value; it produces visible coagulation within two hours.

If the primary particles are of considerable size (10μ or more) sedimentation is so rapid and the Brownian movement so small, that the particles have little opportunity of coming into each other's sphere of attraction. The addition of an electrolyte to a coarse suspension has little influence on sedimentation. For the second coagulating value, therefore, it is the number and size of the primary particles which chiefly influence coagulation, since it is here more a question of measurement of velocity, and the aggregates may sediment before reaching their maximum dimensions. Primary particles not in the immediate vicinity of the rapidly sedimenting aggregates are, therefore, often left suspended in the liquid above the coagulum, rendering it somewhat cloudy. If the electrolyte has been added in sufficient quantity, these particles gradually begin to settle slowly, but it often requires some days before the liquid above the coagulum becomes perfectly clear.

If, on the other hand, sufficient electrolyte has been added from the first, so that all the particles become completely, or almost completely, "discharged," flocculation is very rapid (5—10 minutes). The greater the concentration of the electrolyte, the fewer the number of particles left in suspension. The third coagulating value, therefore, is that concentration of electrolyte which produces complete coagulation within 10 minutes, leaving the dispersion medium above the coagulum perfectly clear.

Some colloids, especially albumen, possess the property of imparting to less stable colloids a greater degree of stability, and of rendering them less

susceptible to the action of coagulates.

As the result of experiments, the writer shows that humic acid possesses this retarding property in relation to clays to a very definite degree.

FAILURE OF BLAST FURNACE STOCK LINE BRICK.—L. P. Ross (*Iron Age*, **2**, 117, 118, 1920). It is generally conceded that the stock line is one of the most important parts of the furnace. Its proper protection against abrasion, etc., is an important point. The writer describes a method of protection by the use of angle plates. These are 6-in. wide, $\frac{3}{4}$-in. thick, 19-in. long, bent to form an angle of $13\frac{1}{2}$-in. $\times$ $5\frac{1}{2}$-in. The plates are built into the brick work the $13\frac{1}{2}$-in. way, and the $5\frac{1}{2}$-in. way they extend down over two courses of bricks; and when laid in rows round the furnace they form a completely armoured stock line. Being small in size they afford a minimum of expansion and contraction. Excellent results have been obtained with this type of protection. After being in use three years, a large number of these plates were employed in relining the furnace.

Prior to the use of shell turnings, due to the sudden and abnormal demand for low phosphorous iron following the outbreak of the war, there had been no trouble with the stock lines. But in three months after these low phosphorous turnings were put on the furnace, one of the stock lines had to be renewed. This was followed by repeated stock line trouble. Careful examination of the condition of the bricks tended to prove that the quality of the brick was not alone responsible for the trouble. On one occasion the bricks on one side of the stock line were completely disintegrated within 3 months, while on the other side and above the level of the stock they were in good condition. A year later, the bricks were found to be disintegrated uniformly round the furnace to about the same depth as in the previous case, from a point where the stock struck the stock line to a point 15-ft. below the closed bell. In the former case it was noted that most of the gas was passing up that side of the furnace on which the bricks had been destroyed. In both cases, the bricks were found to be disintegrated and thoroughly permeated with fine solid carbon. The protecting plates showed carbon absorbtion, and were also covered with a thin film of carbon.

The only change that had been introduced in furnace practice or raw materials was the use of shell scrap. The physical action of the latter being ruled out as the cause of the trouble, an analysis was made to determine its effect upon the gases. This disclosed the fact that, due to the reduction of ore burden (and stone) to reduce the heat to melt the scrap, the gas was greatly enriched in carbonic oxide (the ratio of CO_2 to CO having been raised from 1·83 to 2·87). An analysis of the fire brick used showed Fe_2O_3 1·57; FeO, 0·90; $Fe_2O_3 + FeO = 2·47$.

The action of carbonic oxide on Fe_2O_3 under certain conditions, results in the removal of oxygen from the iron oxide and the deposition of carbon. On the other hand, Bell demonstrated experimentally that considerable quantities of carbon may be deposited without the formation of metallic iron, due presumably to a catalytic splitting up of carbonic oxide into carbon and carbonic acid, the reaction being $2CO = C + CO_2$.

The most favourable conditions for carbon deposition are:

(*a*) At temperatures from 450 to 770°F.
(*b*) In a rapid flow of carbonic oxide.
(*c*) Where the gas carries a high percentage of CO.
(*d*) Where the iron oxide is exposed under pressure.

In comparing these conditions with those existing during the period mentioned above, it was found:

1. That the fire brick contained Fe_2O_3.
2. That the gas contained excessive amount of carbonic oxide.
3. That the bricks were affected in a zone where the range of temperature was probably between 400 and 800°.
4. That owing to the fine magnetic ores that were used, the gas pressure and velocity were high.
5. That the bricks above the level of the stock were not affected.

From these comparisons the following conclusions were drawn:

1. Under the then existing conditions, carbonic oxide penetrated the brick through the pores, joints and round the protecting plates;
2. The iron oxide in the brick split up the CO in the gas into iron, carbon and carbonic acid, or through a catalytic action, the carbonic oxide was split up into carbon and carbonic acid, the reaction being very likely $2CO = C + CO_2$.
3. The carbon thus deposited caused the brick to disintegrate.
4. The shell scrap was the primary cause of the failure of the stock lines.

FIRE CLAY TESTS.—(*The Blast Furnace*, **7**, 620, 1919). To demonstrate the "air-set" feature of their high temperature cement, the Quigley Furnace Specialities Co., of New York, constructed a 9-in. section of wall containing 70 standard fire bricks. The bricks were first dipped in water and then the ends and one side dipped in a batter of "hytempite". They were squeezed together and tamped to insure a close fit, and a strong thin joint was secured. A reasonable time was allowed for the sample wall to set at atmospheric temperature. Holes were then drilled through the wall between the third and fourth courses from the top and hoisting tackle attached. The mechanical strength of the air-set joint has been conclusively proved by transporting the wall section hundreds of miles by motor truck for exhibition purposes. The action of heat would merely strengthen the joints. The weight of the section constructed was approximately 525 pounds, of which 25 pounds represent the quantity of cement used.

COMMERCIAL DEVELOPMENT OF FUSED SILICA.—J. Scharl and W. Savage (*Chem. Met. Eng.*, **22**, 593—5, 1920). At about 1400° the purest SiO_2 commercially available (about 0.2% impure) begins to cohere, and at 1750° to sublime. Contraction in volume on cooling amounts to only 0.07%; this is unexplained. The furnaces used at Keasby, N.J. by the General Ceramics Co. consist simply of a 1-in. Acheson graphite rod 3.5-ft. long embedded in glass sand of the highest grade. Blown ware is made in much the same way as glass-blown products. Semi-translucent fused SiO_2 is made by quickly heating opaque fused SiO_2 for a second time to over 1800° with either an oxy-hydrogen flame or an electric arc.

THE RELATIONS BETWEEN THE CHEMICAL COMPOSITION, MICROSCOPIC STRUCTURE, AND CERAMIC PROPERTIES OF CLAYS.—L. Bertrand and A. Languine (*Compt. Rend.*, **169**, 1171—4, 1919). Microscopic examination of a large number of clay samples showed that they rarely contain mica, and their alkali content cannot be attributed to this origin. The argillaceous material occurs in fine crystalline flakes of kaolinite or as crypto-crystalline or amorphous halloysite. Some clays contain 16—18% sol silica. There is no general relationship between the relative amounts of SiO_2 and Al_2O_3 and ceramic properties such as plasticity and refractoriness. Some clays high in SiO_2 are "fat" because the silica is colloidal; clays rich in crystalline kaolinite flakes are much leaner than clays of the same Al_2O_3 content with a halloysite ground mass. Refractoriness, like other ceramic properties, depends not only on the composition but also on physical factors, which may be demonstrated by petrographic examination.

SOME HIGH TEMPERATURE TESTS OF REFRACTORIES.—A. G. Tarrant (*Engineering*, **108**, 875, 1919). Work done at the National Physics Lab. was reported before the Faraday Society. For determining thermal expansion, test specimens, cylindrical in shape, $\frac{3}{4}$-in. diam. × 4-in. long, were supported axially in a graphite tube furnace. A graphite plunger on top of the specimen carried a knife edge at its upper end extending outside the furnace. The furnace cap carried another knife edge used as fulcrum. Distance between knife edge was only $\frac{1}{8}$-in. Magnification permitted reading expansion to 1 part in 10,000. As a standard for comparison with tests, fused SiO_2 was satisfactory. Tensile strength at temperatures up to 1800°F was measured in a spiral graphite furnace. Test specimens were

in the form of long cylinders. A groove $\frac{1}{8}$-in. deep had to be cut round the middle of the test pieces to ensure regular breaks. Tensile strength was found to increase fairly regularly up to 1500°F. and then fall off. Tensile strength of cold bars, however, seemed to give mere valuable data.

HOW TO TEST CLAY FOR FOUNDRY USE.—H. F. Staley (*Foundry*, **48,** 101—2, 1920). Many failures of fire brick constructions are due to unserviceable mortar joints. Joints should be as thin as possible. Clays for foundry use should not soften before cone 28. Vitrifiable plastic fire clays with high fusing point and ball clays are especially good for batter material exposed to cutting flames or slag action. They are also good for lining ladles and repairing cupolas, usually when mixed with sand or grog. Adding 0·5% NaCl to such mixtures reduces the tendency to cracking. Foundry clays may be divided into 8 classes with typical properties as follows:—

Variety of plastic fire clay			Time of Slaking	Vitrification Temperature	Softening Temp. Cones
Slow slaking,	vitrifying,	refractory	78 min.	1125°	32
,, ,,	,,	non-refractory	117 ,,	1175°	27
,, ,,	non-vitrifying,	refractory	113 ,,	1290°	31
,, ,,	,,	non-refractory	52 ,,	1290°	27
Quick slaking,	vitrifying,	refractory	27 ,,	1200°	32
,, ,,	,,	non-refractory	26 ,,	1195°	24
,, ,,	non-vitrifying,	refractory	6 ,,	1475°	32
,, ,,	,,	non-refractory	12 ,,	1475°	27

Time of slaking is determined by mixing clay with an equal weight of potters' flint, moulding into 1-in. cubes, drying at room temp. and then at 110°, immersing in water at room temp. with the cubes resting on $\frac{1}{2}$-in. mesh wire screen and noting time required for the whole to settle through the screen.

HOW SLAG TEMPERATURES AFFECT FIRE BRICKS.—R. M. Howe (*Brick*, **54,** 143—4, 1919). The method employed for determining the action of various slags at different temperatures was substantially the same as is used by the Carnegie Steel Co. A brick is heated to a definite temp. and 35 grams of slag are placed in a cavity at that temp., and are allowed to act for two hours.

It was first decided to check the influence of time of action, and the quantity of slag used, upon the results secured. The data obtained, tabulated below, led to the conclusion that, when a brick having a cavity $2\frac{1}{2}$-in. diameter is treated with 35 grams of slag and is allowed to react for two hours, satisfactory results were obtained. When the severity of this test was increased 600 per cent. the penetration factor increased only 12·5 per cent.

INFLUENCE OF TIME AND QUANTITY OF SLAG USED UPON PENETRATION FACTOR.

Penetration of	35	grains of slag	in two hours	..	..	·64
,, ,,	35	,, ,,	four ,,	..	..	·68
,, ,,	35	,, ,,	six ,,	..	..	·64
,, ,,	105	,, ,,	two ,,	..	..	·76
,, ,,	105	,, ,,	four ,,	..	..	·72

The following definite method of procedure was then adopted. The test bricks, each having two cavities $2\frac{1}{2}$-in. in diameter by $\frac{1}{2}$-in. in depth were heated slowly to the temperature required. This temp. was sustained for $1\frac{1}{2}$ hours. Thirty-five grams of slag were then introduced and were allowed to react at this temp. for two hours. The bricks were then allowed to cool, were cut through the centre of the cavities, and the penetration noted. The total cross-section of the slag saturated area was first measured by means of a planimeter. The area of the original cavity was deducted from this.

The difference, representing the area of the section penetrated by the slag, when divided by the linear surface of contact, gave a value which represented the sq. inches of penetration per inch of contact.

Six slags were used, with fusion points ranging from 1020°C. for the copper to 1400°C. for the acid open hearth. The three qualities of brick used were designated A, B, and C. The bricks, the slag and the temperature were varied one at a time and the average results tabulated. In each case the slag penetrated more deeply into the brick at higher temperatures. In several cases an increase of 100°C., or less than 10% resulted in almost doubling the penetration.

This increased penetration has several effects in actual practice. When saturated with slag, the bricks are less able at high temp. to sustain the weight of other parts of the furnace. Their refractoriness is also decreased under these conditions.

INTERESTING FACTS CONCERNING REFRACTORIES.—Nesbitt and Bell (*J. Ind. Eng. Chem.*, **11**, 1149—51, 1919). The most important working qualities of silica bricks are shown by the spalling and hot-crushing tests, for clay brick the tests are spalling, hot load and slagging. Variations in service are largely due to differences in grinding, molding, setting, drying, burning or cooling individual bricks. Variations up to 50% in cold and hot (1350°) crushing strength and in spalling tests are shown. Effects of fineness of grinding and of machine versus hand made bricks are indicated.

SUPERIOR REFRACTORIES.—R. C. Purdy (*J. Ind. Eng. Chem.*, **12**, 1151—53, 1919). To meet modern requirements, new refractories will in many cases be found by proper selection of the refractories already available. but cases are multiplying for which new refractory products will have to be developed. Materials such as pure silicon carbide, fused alumina, sintered magnesia, fused spinels, crystallised sillimanite, calcined zirconia, etc., will be brought into more general use for special requirements.

MELTING POINT OF REFRACTORY MATERIALS.—L. J. Dana (*Bull. Am. Inst. Mining Met. Eng*.3153, 1919). The melting point and strength of the brick are affected by the nature of the clays, proportion of flint, calcined and plastic clays, size of particles, water content used in making, pressure in molding, and degree of burning. Two bricks may have the same melting point, but vary greatly in softening point and in resistance to load at relatively high temperatures. Determination of the melting point is of doubtful practical value.

BLAST-FURNACE REFRACTORIES.—R. M. Howe (*Min. and Met.*, 3049—50, 1919). A discussion by J. S. Unger. The need of greater uniformity in the making and use of bricks is emphasised. Figures are given on (*a*) variations in moisture content of pug as the bricks were being made; (*b*) fineness in two pans grinding the same material for the same grade of brick; (*c*) percentage of spalling loss at 1350° for bricks from different makers; (*d*) spalling loss on Chester bricks from different makers; (*e*) crushing strength of 10 bricks from the same truck, crushed at 1350°; (*f*) slagging tests, penetration of molten blast-furnace slag at 1350°.

TREATING A CANADIAN CARBONACEOUS CLAY.—J. Keele (*Brick*, **55**, 45—6, 1919). A somewhat gritty black shale, containing some iron pyrites as well as carbon, was ground to pass a 10 mesh screen and mixed with equal weight of clay. The burning was done in a down-draught test kiln fired with coal and coke. After some unsatisfactory tests, firing was arranged as follows. The test material was burned with a steadily rising temperature at the rate of about 80°F. per hour up to about 1550°. The kiln was held at this temperature for about 4 hours, and then closed and no firing was done for another 3 hours. The firing was then resumed at the regular rate until the finish; total time about 30 hours. The hard, black core, cracking and bloating obtained in the more rapid firing, were entirely eliminated by this method and the bricks were intact.

SILICA REFRACTORIES.—(*Gas J.*, **146**, 240, 1919). Experiments conducted in the laboratory of the U.S. Bur. of Standards showed that, at temperatures from 1250° to 1350°C. there is a slight fluxing of the particles of a raw brick, and that at these temperatures transformation of quartz to the forms of lower specific gravity takes place at a moderate rate. At higher temperatures the transformation takes place rapidly, causing the porosity of the brick to increase unduly. The heating tests with raw commercial bricks brought out the fact that mixtures made from the principal commercial quartzites all transform at about the same rate at a temperature from 1200° to 1500°C., and that the final specific gravities of all are very close together.

QUALITIES AND COMPOSITION OF SILICA BRICKS.—(*Gas J.* **146**, 700, 1919). A paper by M. Dauphins, in the "*Bulletin de l'Industrie Minérale*," contains a summary of the author's experience in the manufacture of silica bricks. For practical purposes, the best measure to determine the refractory quality, is afforded by the temperature of subsidence of a small pyramid similar to the Seger cone, composed of the material of the brick plus 6% of ferric oxide. For the best bricks the temperature is between 1750° and 1735°C., and should not be less than 1710°C. With 97% silica, the temperature should rise to 1750°C. A reduction of 0·5% in the silica corresponds on the average to a fall in refractory power of 1° Seger. Arches of reverberatory furnaces constructed with bricks containing 97% silica have proved capable of withstanding more than 200 operations. The proportion of alumina, which increases fusibility, should not be more than 0·5 to 0·6%. As much as 2% of lime, however, does not appreciably affect fusibility. Porosity is an important factor in the resistance and life of a brick. Only the capillary pores get filled with iron oxide, the larger spaces remaining empty. The perfect brick, the melting-point of which is not reduced by impregnation below the normal temperature of the Martin furnace, is approximately obtained when the initial porosity of the brick does not exceed 18%. The initial density is very important since it gives a sufficient indication of the subsequent swelling. The swelling is greater with bricks consisting of coarser quartz grains; with those formed of impalpable powder it is practically nil. Inasmuch as quartz behaves differently along its different symmetrical axes, heat which produces modifications in the position and proportion of these axes gives rise to deformations corresponding with the degree of development of the crystals. The quartz must, therefore, be ground, first in a macerator, and then between vertical grindstones of 4 to 5 tons weight, so that the coarsest particles will pass through a 10 or 8 mesh. If thus treated, any quartz is suitable for making refractory bricks. The ground silica grains are mixed with milk of lime, to form a sufficiently stiff paste containing 1·5 to 2% of lime. The resistance is greater with a 2% lime content, and is found to be improved the greater the proportion of water which can be used in making the paste. Moulding should be done by hydraulic pressure, the compactness of the brick increasing with the pressure. Solidity of the brick is thus partly a matter of strong pressure. Moulding by pressure also allows of the porosity being reduced by 2 or 3%.

COLLOID CHEMISTRY IN INDUSTRY.—R. C. Coleman (*Chem. and Mat. Eng.*, **23**, 58—9, 1920). A paper read before the Chicago Section of the Amer. Chem. Soc., dealing briefly with the nature of the colloidal state, from mechanical mixtures with particles of 1μ diam., to molecular dispersions with particles 0·1$\mu\mu$ diameter.

CERAMIC PROCESSES ASSOCIATED WITH COLLOID PHENOMENA.—A. V. Bleininger (*J. Ind. and Eng. Chem.*, **12**, 436—8, 1920). A short, general survey of the subject (cf. Sven Oden, *above*).

RESEARCH WORK IN THE CHEMISTRY OF THE SILICATES.—F. M. Jäger and H. S. van Klooster (*Speech.*, **52**, 256—7, 1919). An article giving certain data on the meta and orthosilicates of the divalent metals: Beryllium, Magnesium, Calcium, Strontium, Barium, Zinc,

Cadmium and Manganese. The silicates were obtained by sintering a mixture of quartz and the carbonate or oxide of the metal in an iridium-free platinum shell in an electric furnace, followed by fusing in a Fletcher furnace. The silicates of Ba, Sr, Be, Zn and Cd are white and crystallised; a blue or violet tint is sometimes observed in obtaining zinc silicate, whilst Mn silicate fuses brown. The fusing points of the Ca, Sr. and Ba-metasilicates rise with the increasing atomic weights of the respective metals, whilst the Mg, Zn, and Cd-metasilicates fall with the increasing atomic weights of the metals. Similar relationships between the orthosilicates can not yet be determined, the requisite data not being available on account of the high fusing temperatures. Ba_2SiO_4 and Sr_2SiO_4 have fusing points round about 2200°; the temperature for Be_2SiO_4 is still higher; it might possibly be used, therefore, as a refractory material.

SILICA ACID AS A MEDICINE.—(*Ker. Rund.*, **28**, 178, 1920.) An article dealing with the healing properties of silicic acid for certain diseases, particularly consumption.

QUARTZITE AND SILICA BRICKS.—Wernicke (*"Stahl und Eisen,"* 1920, No. 13). The manufacture of silica Bricks from pure Quartzite mixed with a small percentage of lime as a binding material, was first undertaken about a century ago in England. A very pure sandstone, found in the Neath Valley, in Wales, was mixed with 2% of lime to form Dinas Bricks. Later on, attention was drawn to the so-called "Findlingsquartzite," found in the area between the Rhine, Sieg and Lahn rivers in Germany. Dinas Bricks made from this material showed more favourable pyrometric qualities than the others, since no considerable expansion took place after the first burning.

In the manufacture of Fire Bricks, three different kinds of quartzite, belonging to three different geological formations, are employed, viz.: Quartzite, Sandstone, and "Findlingsquartzite." Quartzite is a marine deposit of the Devonian period, and thus is a palæozoic formation; sandstone a brackish water deposit of the anthracite formation, whilst "Findlingsquartzite" belongs to the Tertiary period.

All these quartzites contain a high percentage of silicic acid, in the case of the Taunus variety up to 99·8%. They have a correspondingly high melting point. They can be mixed with clay in the manufacture of fire bricks since the quality of quartz to expand in the fire is counterbalanced by the tendency of the clay to decrease in volume. In making silica bricks (lime and quartzites) it often happens that, of two quartzites, exactly similar in appearance and chemical composition, and having the same melting-point, the one will prove eminently suitable whilst the other is quite useless.

Experiments carried out in France, have shown that any quartzite can be used in the manufacture of silica bricks, if it is first ground to a very fine powder. The high cost of this process, however, prohibits its use in practice.

In the refractory industry, the old method of judging the quality of a quartzite according to its chemical composition and resistance to heat, is now useless. Its usefulness can only be ascertained with certainty by the help of the polarising microscope.

Microscopic investigation in polarising light, shows that quartzite is purely crystalline in structure. Quartz grains of considerable size have been formed by the very gradual disappearance of silicic acid from the waters of the sea and have been compressed into a firm structure by subterranean pressure.

Carbonated sandstone owes its origin to similar causes. The microscope shows it to consist of grains of moderate size, separated for the most part by a granular mass. There is no actual basic cement.

"Findlingsquartzite" is of quite another formation. Very small grains, rounded in form, lie separate from each other embedded in an amorphus mass, the basic cement. Whilst the crystalline rocks were precipitated

out of the water, and consolidated under pressure, the amorphous quartzites were formed of deposits of extremely finely granulated sand cemented together by silicated gel brought down by water penetrating from the surface. This extremely hard, amorphous quartzite is found only in the brown coal formations of the Tertiary period.

The well-known tendency to expand in the fire shown by all quartzites, is due to their gradual transformation, without chemical change, into the tridymite form, which takes place after a lengthy exposure to a temperature of about 1450°. Simultaneously, a reduction of the Sp. Gr. from 2·65 to 2·32, and an increase of about 14% in volume take place. The change into the tridymite form does not occur during the initial burning in the manufacture of the bricks; on the contrary, the microscope shows that the original appearance of the quartz grains remains practically unaltered, with the exception of numerous cracks and fissures, which vary according to the size of the grains. This cracking is most apparent in the crystalline quartzites. It will be seen, therefore, that the miscroscope offers a ready means of ascertaining the quality of any brick.

Experience has shown that it is not necessary to burn silica bricks until the change from quartz to tridymite is complete. In doubtful cases, the microscopic test of a quartzite may be supplemented by observing the minimum time taken by the brick to reach its maximum expansion at a temperature of about 1450°. This occurs before the change from quartz to tridymite begins. The minimum expansion period varies considerably according to the nature of the quartzite. The amorphous variety attains its maximum expansion of about 12%, accompanied by a decrease in Sp. Gr. from 2·65 to 2·4, after the first burning, subsequent variations being negligible. Sandstone reaches its maximum expansion after the second or third burning, whilst the crystalline quartzites exhibit very varying and even erratic qualities, the maximum expansion not being complete after a number of burnings. The minimum expansion period test should, therefore, be taken in conjunction with the microscopic examination in the case of all quartzites, which, according to their structure, cannot definitely be classified under one of the above mentioned three varieties.

The smaller the quartz grains in the quartzites and the more regularly they are distributed in the basic cement of the amorphous variety, the less disturbing is the effect of high temperatures upon them. The fine powder into which, according to the above mentioned French experiments, the quartz must be ground, is already to hand in the amorphous quartzites in a natural condition. These quartzites always contain a certain quantity of accessory ingredients which assist in the change from quartz to tridymite.

Only the silica bricks made from the amorphous quartzites are capable of satisfying the highest demands of the metallurgical industry. They have proved themselves the best furnace material both in the Siemens-Martin and in the electro-steel furnaces.

There are nine photographic illustrations and 3 diagrammatic representations of the behaviour of different quartzites under high temperatures.

ACTION OF CARBON ON MAGNESIA AT HIGH TEMPERATURES.—O. P. Watts (*Trans. Amer. Electrochem. Soc.*, 1907, **11**, 279—88). When a granular carbon resister is very strongly heated in an electric furnace lined with magnesite bricks, the carbon apparently volatilises simultaneously and condenses on the walls of the furnace. The conclusion arrived at is, that carbon and magnesium oxide react at extremely high temperatures according to the equation—$MgO+C=Mg+CO$. This reaction is reversible, and at a lower temperature the products on the left side of the equation are again formed. In another instance, magnesite tubes were embedded in carbon; in this case the tubes disappeared entirely, leaving a hollow space in the carbon. The author is of opinion that this was not a case of chemical combination, but simply of a physical mixture of magnesia and carbon. He succeeded in making a similar product by grinding and mixing the two materials.

The reduction of magnesium oxide is found to be effected more rapidly by certain carbides than by pure carbon. The carbides of chromium, iron and nickel are very active, as are also siloxicon and carborundum. Copper and tin, however, have little, if any, action.

THE REFRACTORY PRODUCTS INDUSTRY.—J. Bied (*Chim. Ind.*, **1**, 579=141T, 1918). An illustrated general review of our present knowledge, with special reference to conditions in France. All recent advances are ascribed to the efforts of Le Chatelier and Bogitch, or those who have received inspiration from their work.

Basic Materials. Dolomite is subjected to fritting or dead burning at a high temperature in a special cupola. The object is to render the product more stable in presence of water, and at the same time to increase density and eliminate shrinkage. The dead burning is just sufficient to enable dolomite to be preserved for two or three weeks, scarcely enough time for transport and use. The slaking of lime is retarded by increase in amount of impurities and by higher burning temperature. The phenomenon is usually limited to a few days, but if the grains of lime are scanty and surrounded by inert material, slaking takes place slowly. Bricks made from hammerslag, and tiles made of marl and easy fired, sometimes scale off and split from this cause after a certain time in use. With Magnesia, especially after firing at a high temperature, the slaking is much slower than with lime. When magnesian limestones are burned at low temperatures the magnesia is slaked at the same temperature as the lime and the product can be safely used for constructional purposes. On the other hand, it is recognised that Portland cement should not contain more than three to four per cent. of magnesia. The magnesia, having been then burned at a high temperature, slakes very slowly, often a year or two later, to the great detriment of walls where magnesian cement was used, as has been ascertained officially. As regards impurities, carbonate of iron (which is isomorphous with Magnesium Carbonate, and very evenly distributed when occuring naturally along with it) especially prolongs the time during which dead-burned dolomite can be preserved. Steel makers willingly receive slightly ferruginous dolomites. The author has several times found that by intimately mixing five to six per cent. of pure kaolin with finely triturated dolomitic carbonate, then agglomerating again, and burning, the product was as difficult to slake as dead-burned magnesia. If such a product should behave as well in a Siemens-Martin furnace as dead-burned natural dolomite (and there seems to be no obvious reason why it should not), it would be as easy to obtain as artificial cement, and probably it would compete with magnesia, especially as magnesite does not occur in France. Very pure dolomitic sands occur in France, and there is no practical difficulty in introducing into these sands, and uniformly distributing, the necessary quantity of kaolin; the mixture, agglomerated and strongly heated, should give a dolomite perfectly resistant to slaking.

The picked dolomite from the kiln is ground for use. For ramming it is triturated a little less finely than for bricks; the pieces do not exceed 5 to 6 mm., and 30 to 40 per cent. of the material consists of fine particles. After leaving the kiln dolomite keeps about a fortnight, but not so long when in triturated form, so that it has to be used at once. For making bricks, as well as for ramming, dolomite is mixed with coal tar, which should be boiled previously for at least five hours. The operation is carried out in vertical cylindrical vessels, heated by a fire, and two-thirds filled to avoid overflow. Well-boiled tar is very viscous, and forms long threads difficult to break. The mixture of tar and dolomite is made under revolving millstones. For making into bricks it is taken to the press at once, the pressure applied being 400 to 500 kg. per sq. cm. of brick. The moulded bricks become very hard after 4 or 5 hours. They should be used at once, as they keep only 2 or 3 days; they are burned again in their place on raising the furnace to white heat. Special pieces like Bessemer bottoms are placed in casting moulds, and heated to 900° or 1000°C. for 8 to 10 days in reverberatory furnaces.

A lining thus prepared is able to last for 140 to 150 charges.

Before 1914, nearly all the magnesia used in France came from Styria, partly as dead-burned magnesia, partly as bricks. From comparison of analyses of magnesia and commercial bricks, the latter containing much more lime and silica, and correspondingly less magnesia, it is inferred that the bricks were made from dead-burned magnesia with artificial cement. A special German brick was probably made from a mixture of bauxite and magnesia. Bricks of Styrian magnesia, containing much iron with also lime, are relatively little liable to slaking, but they soften at a comparatively low temperature and become plastic from 1350°C. upwards, their resistance falling from 66 kg. per sq. cm. at 1300° to 4 or 5 kg. at 1400°C. They are flattened at 1500°C. at a pressure of 36 kg., and at 1600°C. at a pressure of 1800 kg. Bricks made in France from Eubœan magnesia are agglomerated by pressure without any addition, and have the same analyses as the dead-burned material. The specific gravity of well-burned material of this type varies from 3·40 to 3·50.

Magnesia is used with 8 to 10 per cent. of well boiled tar, to be rammed down, but it is often preferred to use magnesia bricks

Magnesia bricks are made from dead-burned magnesia (two parts passing 20 lawn to one part impalpable) mixed with a little water, and subjected to a pressure of about 500 kg. per sq. cm. The bricks are then burned again, in Mendheim kilns, or in tunnel kilns, or in intermittent kilns with mouths. It is good to just reach 1550°C., but not to exceed it, for from this temperature Grecian magnesia becomes plastic like Styrian magnesia. Kilns for magnesia bricks should have a low stacking height, 2 to 2·5 m. In intermittent kilns there is reason for taking special precautions at the time of kindling, to avoid losses from slaking. This liability to slaking is a defect of Grecian magnesia. Grecian bricks are completely spoiled in contact with water vapour in less than ten hours, sometimes in only two hours. Grecian magnesia also contracts very much when strongly heated for a long time.

In spite of its defects, many steel makers reckon that Eubœan bricks properly used make more tappings than Styrian bricks.

Italian magnesite is also briefly alluded to, including analyses of dead-burned material and bricks.

Alumino-Silicious Products. Reference is made to Mellor and Moore's paper on refractoriness under load (TRANS., **15,** 1916), and to Le Chatelier and Bogitch's paper in *Compt. rend.*, vol. 164. Brief reference is also made to some results from either the laboratory of la Société Pavin de Lafarge or a works at Bolléne, obtained on test pieces made of equal parts of silicious sand and Bolléne clay. Bauxite and chromite are also briefly alluded to, including a mention of pre-war German "dynamidon" bricks of fused bauxite.

Siliceous Products. The transformation of quartz is discussed, and the chief factors concerned—duration of heating, size of grain, and nature of the quartz. In connection with a brief notice of the manufacture of silica bricks is given a diagrammatic scheme for the manufacture, indicating the relations between the different parts of the plant, etc. Other topics considered are uses of silica bricks, deterioration of refractory materials, quality of silica bricks, resistance under load, expansion, specific gravity, apparent density, and crushing resistance, etc. As regards specific gravity of silica bricks the three following propositions are cited: (1) certain bricks can have a specific gravity of 2·50 and be excellent; (2) most bricks cause inconveniences in use if the specific gravity is above 2·40; (3) all bricks fired long enough can attain the specific gravity 2·35. At least at the outset, the upper limit of specific gravity should be fixed at 2·40.

STANDARD SCREEN SCALE FOR TESTING SIEVES.—(*Trans. Amer. Inst. Min. Engrs.*, Preprint, 945, 1917). Relates to a standard screen scale recommended by a conference—including representatives of Committees of many scientific and technical societies, and of public organizations like the U.S.

Bureau of Standards, U.S. Bureau of Mines, and U.S. Geological Survey, as well as of various firms connected with the glass, abrasive, mining, chemical, graphite, and other industries—for general adoption by scientific, technical, and engineering Societies and Committees, public bodies, and private firms.

UNIFORM SIZING DIAGRAM FROM DIFFERENT SCREEN STANDARDS.—J. Randall (*Trans. Amer. Inst. Min. Engrs.*, Preprint, 1467, 1917). A general discussion, with explanation and diagram based on an actual example.

BALL MILL CRUSHING.—R. B. Gottsberger (*Trans. Amer. Inst. Min. Engrs.*, Preprint, 1918). Discussion of paper by C. T. Van Winkle, on "Recent Tests of Ball-Mill Crushing," published in the January Bulletin (No. 133) of 1918.

THE DRIFTON BREAKER.—E. P. Humphrey (*Trans. Amer. Inst. Min. Engrs.*, Preprint, 199, 1918). A description of a Coal breaker.

AUTOMATIC FILTER.—G. S. Brooks and L. G. Duncan (*Trans. Amer. Inst. Min. Engrs.*, Preprint, 1933, 1918). Relates to gas-filtering apparatus used in the removal of dust from crushing and milling plants, in the manufacture of zinc oxide, and on blast-furnace fume and sintering furnaces. The filters take the form of bags made of fabric.

HEATING OF COAL IN PILES.—C. M. Young (*Trans. Amer. Inst. Min. Engrs.*, Preprint, 211, 1918). Relates to the spontaneous heating of bituminous coals piled in heaps or bins. It is inferred that a comparatively safe way to store coal is to use enough of the fine sizes to fill the space as completely as possible, and to pack the coal tightly. Loosely packed piles of mixed sizes seem to be the worst.

GRAIN GROWTH PHENOMENA IN METALS.—Z. Jefferies (*Trans. Amer. Inst. Min. Engrs.*, Preprint, 2063, 1917). A discussion of the factors involved.

ASSAY FOR CORUNDUM BY MECHANICAL ANALYSIS.—W. S. Hutchinson (*Trans. Amer. Inst. Min. Engrs.*, **46**, 1039, 1913). Relates to a method used to determine the corundum contents of samples of hard crystalline gneiss containing both corundum and red garnet, the other chief minerals found in the samples including quartz, felspar, and mica.

FLOW OF SAND AND WATER THROUGH SPIGOTS.—R. H. Richards and B. Dudley, Jun., (*Trans. Amer. Inst. Min. Engrs.*, Preprint, **67**, 1918). Report of experiments having a bearing on ore-dressing operations.

A COMBINED HYDRAULIC AND MECHANICAL CLASSIFIER.—M. G. F. Sohnlein (*Trans. Amer. Inst. Min. Engrs.*, Preprint, 715, 1916). An illustrated description.

TESTS ON THE HARDINGE CONICAL MILL.—A. F. Taggart (*Trans. Amer. Inst. Min. Engrs.*, Preprint, 7191, 1917). An illustrated account of grinding tests. Among the conclusions are that the ball mill works more efficiently on material of intermediate size (0·5 in. to 0·75 in. average) than on either a coarser or a finer feed; that steel balls are much more efficient crushing media than pebbles; that increase in the weight of the ball load (other conditions remaining constant) increases the ratio of production and the relative mechanical efficiency of the mill; that the relative mechanical efficiency of the ball mill increases with the average size of ball in the crushing charge up to 5 in. average diameter, and also with the rate of feed to the point of overload; that the relative mechanical efficiency of the mill (other conditions being constant) is a maximum at between 40 and 50 per cent. moisture content in the feed; that the relative mechanical efficiency in wet crushing is decidedly greater than in dry crushing.

NOTES ON THE THEORY AND PRACTICE OF BALL-MILLING.—P. R. Hines (*Trans. Amer. Inst. Min. Engrs.*, Preprint, 251, 1918). A dis-

cussion with graphs and other illustrations, particularly with reference to peripheral discharge mills.

CHEMISTRY OF SILICATES.—C. C. Voght (*Scientific American Supplement*, No. 2218, July 6, 1918). Special reference is made to their use in dental operations. A silicate filling material consists of a powder and a liquid to be mixed with it. The usual constituents of the powder of a silicate are silica, lime, alumina, sodium and potassium oxides and fluorides, with sometimes oxides of zinc, magnesium, beryllium, strontium, phosphorus, boron, titanium, etc. The development of a material of the silicate type was due to the demand for a translucent filling material which could be inserted while plastic as is the case with a zinc cement. Such a material would equal porcelain in appearance, and the mode of application would be far more simple than for the porcelain inlay.

A hardened pellet of oxy-phosphate of zinc shows under the microscope masses of translucent zinc phosphate holding together the opaque grains of the zinc oxide. Had the zinc oxide itself been translucent there would have been no need for the silicate.

The method of production of a silicate powder is to prepare a strongly basic silicate which is itself translucent. This basic material will readily react with the liquid and being itself translucent it will form a translucent mass with the translucent binder. The various components are sifted and mixed, and then fused to a homogeneous liquid at 2000° to 2500°F. (1093° to 1371°C.). The melted product is poured out from the crucible, afterwards ground in ball mills and sifted through a fine sieve, after which it is ready for use. The actual chemical composition of this fused material is not known, but probably it includes calcium aluminium silicate, sodium and potassium aluminium silicates (felspars), with fluosilicates and sometimes borates, phosphates, and titanates; certainly the melt is essentially a strongly basic silicate.

The liquid consists of phosphoric acid diluted with water to which one or more metallic oxides have been added so as to dissolve completely in the acid solution. The oxides added are those of calcium, strontium, beryllium, zinc or aluminium. The dissolved oxides form the corresponding acid phosphates, the presence of which decreases the rate of setting of the mixed silicate. The liquid is really a concentrated solution of metallic acid phosphates with some free phosphoric acid. On adding the powder to the liquid the following reactions probably occur: acid phosphates of calcium and aluminium are formed (along with water), and these with the acid phosphates already present in the liquid react with more of the basic powder, producing normal phosphates and water. It is these normal phosphates that possess the adhesive and cementing qualities, and so the more thorough the mixing the better the filling made from this class of filling materials. Change of concentration of the liquid materially modifies the rate of setting of a silicate; increase of concentration retards setting, whereas addition of water causes a too rapid setting (as when a stopper is left out of a powder bottle and the powder absorbs moisture from the air).

The hardening of silicates takes place in two stages, the initial action being complete in 5 to 20 minutes, while the secondary hardening extends over months and perhaps even years. The maximum change of physical properties takes place in 24 hours, only very slight changes taking place after that. The initial hardening is probably due to the formation of crystalline salts by combination of water with the phosphates formed during the mixing. The acid phosphates first formed are extremely soluble in phosphoric acid, and as they are converted into the very insoluble normal phosphates they combine with water and crystallize out into so dense a mass of minute, interlocked crystals that the individual crystals cannot be detected even by a high-power microscope, especially when formed from highly concentrated solutions. The excess of powder over that required for the formation of these crystalline salts is held by the crystals just as sand and gravel are held by the cement particles in concrete. The initial hardening is analogous

to the setting of an oxyphosphate of zinc cement. The secondary hardening seems to be due to the same general causes as the setting of Portland cement; it is most probably due to the combination of water of crystallization with calcium and aluminium silicates (to form crystalline salts), and to the desiccation of colloids, both of these reactions being slow. A silicate when hardened is hydraulic, and must remain in the presence of water to be at its best—hence silicates lose their translucency and show signs of cracking on the surface owing to loss of water of crystallization on exposure to the air. A filling finished at the same sitting as its insertion often proves satisfactory, but it cannot be as perfect as one finished 24 hours later (after the secondary hardening). For the best results the filling should be coated with a varnish or other waterproof coating to prevent moisture from interfering with its proper crystallization.

INDUSTRIAL USES OF REFRACTORIES.—H. C. Arnold (*Iron Trade Review*, **61**, 1212, 1917). A general review of the properties, occurrence, preparation, and testing of the commoner refractories. A refractory as used for metallurgical work is defined as any substance, applied as a lining or a container, which resists the action of heat and other actions occurring during the operation. No substance possesses all the properties needed, but combinations of substances can be used, including compounds of alumina, silica, lime, magnesia, chromic oxide, carbon and a few metals (such as nickel and platinum). The selection of a refractory, and even the design of a furnace, will depend largely upon the nature of the slag formed and the temperature required. Acid refractories are those high in silica, such as ganister and quartzite and their products. Basic refractories include magnesium carbonate and dolomite, the latter being a mixture of magnesium and calcium carbonates. Neutral refractories include fireclays, pure or nearly pure alundum (made from bauxite), silicon carbide and related compounds, carbon, chrome iron ore, etc.

Of acid refractories, quartzite, ganister, sandstone, granite, gneisses, and rhyolites have been used in the natural state as the linings of furnaces—large blocks being trimmed to shape for the purpose. Though they were well able to resist the temperatures used, rapid heating and cooling caused splitting, cracking, and spalling. Siliceous materials high in quartz suffer permanent expansion, and are much used where such expansion is not harmful. The natural rock is used as a quartzite cement and mortar in sintered bottoms of open-hearth furnaces, but in the roofs and side walls Silica bricks are used instead of the natural blocks. The quartzites should contain 96 to 98 per cent. silica, 1·75 to 2·5 alumina and iron oxide (serving as a bond), very little lime and magnesia, and less than 0·5 per cent. alkalies; those used in America (Medina, Baraboo, and Alabama quartzites) are hard and break up into angular fragments with no rounded grains. The manufacture of silica bricks includes grinding, mixing, forming, drying, and firing. Formerly semi-drying, re-pressing and then complete drying were included, but by working the batch stiffer, re-pressing has been eliminated. The different operations of crushing, grinding, moulding, drying, and firing are briefly described, and also tests for resistance or abrasion, cross-breaking strength, compressive strength, thermal conductivity, refractoriness, load-carrying capacity at high temperature, and permanent expansion after the first firing.

The linear expansion of silica bricks ranges from 3·0 to 4·5 per cent. Bleininger showed that permanent expansion increases directly with the temperature (not with the development of cristobalite), and suggested cones 18 to 20 as the minimum firing temperature for silica bricks. Allowance should be made for the permanent expansion of silica bricks placed in furnace walls. Rapid heating or cooling weakens the bricks.

The most common materials used in basic and neutral refractories are the crystalline or amorphous mineral magnesite, and dolomite. Other magnesian minerals which have been used alone and in combination with fireclays as a heat resister include the various forms of asbestos, serpentine,

stealite, and soapstone. The use of lime alone as a refractory has not been successful, partly because of its affinity for moisture and because of the formation of calcium salts of iron oxide.

Magnesite bricks are composed of 15 to 25 per cent. low calcined magnesite, 2 to 3 per cent. iron oxide added to increase the bond, and dead-burned magnesite. Iron oxide is added with the original raw batch of calcine and is added to the final mixture in this form. These two ingredients, calcined magnesite and dead burned magnesite, are mixed together. Sometimes a binder is added, such as tars, alkalies, etc., at the expense of the caustic magnesite, but the common practice is to use no bond. The raw bricks have weak bond, and in firing they are arranged in two layers or two bricks on end (in compartments built of silica bricks), so that no brick has to bear a greater weight than that of the brick on top of it. The firing temperature varies from 2160° to 3000°F. (1182° to 1649°C.), the temperature being raised slowly to avoid cracking.

Dolomite is cheaper than magnesite, and has been much used instead of it as a lining, but it is not satisfactory when made into bricks, owing to its tendency to crack at high temperatures.

The properties and methods of manufacture of fireclay refractories are also discussed, as well as the tests applied for determining their properties.

FACTORS AFFECTING SELECTION OF INSULATORS.—A. O. Austin (*Electrical World*, **70**, 905, 1917). With the growth of a system and the consequent increase in hazard for oil switches, transformers or other apparatus, certain types have been discarded, although they may have given very satisfactory operation at the same voltage when the system was smaller. It is seldom that the growth or size of the system receives consideration when it comes to the performance of the insulator or line, where it may be even more important.

The factors which affect the performance of the insulator or the reliability of a given line are often far more important in producing reliability than additional circuits, the reinsulation or the use of a larger size insulator on the system, and should be given careful attention in the construction of a new system or in the operation of an old one. If the value of reliability to the system can be determined some basis for the expenditure in the transmission line will be had. The value of reliability is largely determined by three conditions: investment depending upon the line, nature of the load and competition.

Other points discussed are factors affecting the line, including size of system, construction, method of operation, local conditions, and electrical characteristics of apparatus or line. Reference is made to advantages from splitting up system.

EXPERIMENTAL INVESTIGATION OF PORCELAIN MIXTURES.—G. I. Gilchrest and T. A. Klinefelter (*Electric J.*, **15**, 77, 1918). The desirable qualities in electrical porcelain are high dielectric strength and insulation resistance, high mechanical strength (toughness and resistance to shock), and high resistance to temperature changes. In the investigation cup-shaped test-pieces were made for testing, and the field of investigation ranged from low felspar to high felspar, low clay to high clay, and no flint to high flint—including practically all commercial white ware bodies made. The body mixtures were all made in a laboratory, being blunged in ball mills, screened, filter pressed, pugged and jiggered in a manner corresponding as nearly as possible with the procedure in works.

The difficulty of keeping the materials suspended in water and well mixed increases rapidly with increase of felspar and flint, especially of felspar, the effect of the flint being less noticeable unless the clay content is quite low. In either case the felspar and flint tend to settle out if the slip is not kept in rather violent agitation. A body low in clay but high in felspar and flint would be very undesirable from the standpoint of mixing of the slip. With certain plastic clays containing much vegetable matter, the resulting porcelain body is liable to contain many small blebs caused by the

burning out of vegetable matter during firing.

The ease with which bodies filter-pressed and pugged varied in about the same manner as did the ease of mixing. It is essential that the body when taken from the pug mill should have a definite percentage of water, for otherwise the material will not work properly when it is later formed into shape. The substitution of a proportion of china clay for ball clay tends to make the body more open and has the same effect as decreasing the total clay content; as regards shaping it has the same effect as an increase of flint at the expense of clay.

Samples were fired from cone 7 (1270°C. or 2318°F.) to cone 12 (1370°C. or 2498°F.). Translucency was found to increase in general with increase of felspar or decrease of clay, the kind of clay having a very marked effect. The degree of vitrification often has more effect than a considerable change of ingredients, for some mixtures that are opaque at cone 7 are decidedly translucent at cones 10 to 12. The colour appears to vary directly with the increase or decrease of the clay content; the colour becomes lighter with increase of firing temperature. The roughness of a fractured surface increases directly with the flint content. The specific gravity ranged from 2·46, for bodies of high clay (no china clay), high felspar, and low flint, to 2·08, for bodies of high clay (mostly china clay), low felspar, and high flint. The absorption ratio (or relative porosity) depends largely on the proportions of fluxing material in the body and the degree of vitrification, and increases with increase of flint at the expense of either clay or felspar, and also with increase of the proportion of china clay. In general, it appears that if the clay used is mostly ball clay the shrinkage varies directly with the clay and indirectly with the flint. When a considerable proportion of China clay is used the felspar also exerts a material influence towards increasing the shrinkage. The shrinkage varied from 5·5 to 27·5 per cent., the former with low clay and high flint, and the latter with high clay and low flint.

The dielectric strength varies directly with the felspar content when this is high, but with low felspar its value also varies directly and quite rapidly with the clay content. The dielectric strength varies inversely with increase of flint or china clay, and also increases rapidly as the firing temperature increases. The highest values occur with high felspar and low flint, and the lowest values occur with low felspar and high flint, the range of dielectric strength being from 5000 volts per 100 mils to 39,000 volts per 100 mils. The average dielectric value of the bodies that would be practical for electrical porcelain was apparently decreased about 6 to 10 per cent. during testing by increase of temperature from 79°F. (26°C.) to 170°F. (77°C.). The temperature of firing affected the insulation resistence much less. The resistance to impact was found to vary directly with the flint. Increase in the proportion of china clay decreases the strength, but to a much smaller extent than increase of flint increases it. Increase of firing temperature also decreases the mechanical strength, especially with high felspar, a difference of 30 per cent. being often found in samples of the same body mixture fired at different temperatures. Bodies of greatest resistance to impact had high flint, low clay, and medium felspar contents, and those of lowest resistance had no flint, high clay, and high felspar contents. The comparative relations between the highest and lowest bodies were about 4 to 1.

Resistance to local heat application varies directly with the clay content and indirectly with the flint content. The most resistant bodies have high clay and low flint, while those of least resistance have low clay and high flint. The comparative relations between the highest and lowest bodies were about 5 to 1.

Summing up, high dielectric strength appears to be characteristic of a high felspar content, high mechanical strength of a high flint content, and high resistance to local heating of a high clay content. Though all three properties in the very highest degree are not likely to be found in any one body, they can be obtained in a very good working percentage for each one. Each property can be helped or raised in a body by the use of certain

clays or certain mixtures of clays or by variation of the firing. Sometimes this occurs at the expense of another property if care is not exercised. For given materials and firing temperature a maximum of any one property can be obtained and a fair or good working percentage of one or both of the others, or a very fair medium of all three properties. This latter is the more logical if due consideration is given to the commercial application of the finished product.

A number of triangular diagrams and other illustrations are given.

THE REVERSIBLE EXPANSION OF REFRACTORY MATERIALS.—H. J. Hodsman and J. W. Cobb (*J. Soc. Glass Tech.*, **3**, 201, 1919). A description of the testing apparatus, and of tests to prove its efficiency, together with results of tests on kaolin, alumina, silica, fireclays, bauxitic clay, ball clay, mixture of clay and silica, magnesia brick, and carborundum. The results disclose great differences in the behaviour of different refractories when heated up to 1000°C. Calcined alumina, magnesia brick, carborundum, calcined kaolin, and hard calcined ball clay expand regularly over the whole range, which is not suggestive of molecular changes. In the case of silica the inversion of α to β quartz, accompanied by a very large expansion between 500° and 600°C., is followed by a range from 600° to 1000°C. with practically invariant dimensions. Burned fireclay containing free silica reveal the same change, though not so strongly marked. Some clays resemble kaolin more nearly, while others approach silica in this respect. A mixture of half fire clay and half silica (containing about 89 per cent. silica) behaves like silica. Glass pot fireclay mixtures were not found materially different from the fireclays. It is evident that pots made from kaolin ball-clay mixtures or from clays containing no free silica (quartz) will be quite different in their behaviour on heating and cooling from pots of which the basis is fireclay, and also that great care will be necessary in the treatment of pots of the latter kind in the range 500° to 600°C. On cooling clay and silica, the contraction just below 600° actually exceeds the corresponding expansion on heating. This is specially marked with silica and fireclays, and suggests that a rapid cooling of ware or glass pots through the region 600°—500°C. must be fraught with quite special risk of cracking. Most refractories examined expanded roughly, $\frac{1}{2}$ per cent. up to 1000°C., but magnesia brick more than twice this amount.

AUTOMATICALLY RECORDING METHODS OF SOIL ANALYSIS.—Sven Oden (*Bulletin Geol. Inst. Univ. Upsala*, **16**, 15, 1919). The methods of Nöbel, Schöne, Hilgard, Kopecky, and others, which make use of flowing water for separation of the particles, are tolerably perfected, and are automatically effected, but only permit of the separation of somewhat coarse particles perhaps up to 10μ (=0·01 mm.). If after the simpler analysis by elutriation it is desired to accomplish a carefully carried out separation of particles to perhaps 0·5μ, this necessitates not only great precision and attention for several weeks, but also favourable temperature conditions in the workroom, in order to obtain that result by repetition of the analysis.

There are very serious considerations against these methods. First, there is the velocity with which small particles sink in a liquid, approximately inversely proportional to the internal friction. But the internal friction of water changes from 25° to 10° not less than 46 per cent., and analyses which are carried out in Egypt or Scandinavia, in winter or summer consequently with changing laboratory temperature, come out quite different. Secondly, if it is not possible to work with constant temperature, attention must be paid especially to uniform warming or cooling of the elutriation cylinder, since otherwise convection currents quite derange the results. If one wall of the room is considerably warmer than the other the unfailing appearance of such currents can be noticed.

The characterization of different materials by the sizes of the grains present should be illustrated graphically by a curve rather than by abstract numerical data.

Starting from the consideration that it is an unnecessary labour to isolate and weigh entire fractions, the author has been engaged since the spring of 1913 in working out a new method for the mechanical analysis of soils, etc. On the general principles as well as the simpler arrangement of the original test, preliminary communications have already been made elsewhere (Swedish patent 41,184 of March 27, 1915, *Intern. Mitt. f, Bodenkunde*, **5**, 257, 1915, *Koll-Zeits.*, **18**, 33, 1916). Meanwhile the first apparatus was affected with several defects and insufficiencies. For a year and half he has been in a position to revise several times the whole arrangements in all details, and to carry out automatic recording, and has now reached certain conclusions. He was not aware when he began that certain of his conclusions had been already proved theoretically and experimentally by T. Schloesing, Sen. (*Comp. rend.*, **136**, 1608, and **137**, 369, 1904), and in quite another way. But he considers it important to investigate accurately once more within what limits the rules relative to the ratio between the inverse height of fall and speed of sedimentation and the absolute quantity of particles can be considered as admissible, and also to prove the accuracy of the same as regards still finer grained material than that used earlier. On the other hand, in all the experiments the tests were chosen so that no coagulation of the particles took place.

The preliminary treatment for the mechanical analysis and the omission of the difficulties arising with calcareous clays are dealt with in another paper. All measurements given in the present paper have been carried out with the automatic recording apparatus. Attention is called to this, because there are small differences with earlier published works. But this only concerns details, and is to be traced to inaccuracies and derangements in the old apparatus.

The movements of small particles in liquids is discussed, applying Stokes' law, from which are obtained the theoretical equations:

$$6\pi r\eta v = \frac{4}{3}\pi r^3 (\sigma-\sigma_1) g, \text{ or } v = \frac{2}{9} g r^2 \frac{\sigma-\sigma_1}{\eta}, \text{ or } v = Cr^2$$

where v is the downward velocity of the particles, w the resistance of the liquid, η the internal friction of the liquid, r the radius of the particle, σ the specific gravity of the particle and σ that of the liquid, g and π have their usual signification.

It is assumed that in the general equation of movement the members of higher order can be left out of account. The external conditions which permit that assumption are: (1) that the particles (molecules) of the liquid are small in comparison with the moved particles, (2) that the liquid is of infinite extent in comparison with the sinking particles, (3) that the particles are rigid and smooth, (4) that no slipping takes place between particles and liquids, and (5) that the velocity is small (or that the radius of particle is not too large). The critical radius, above which the velocity is greater than that corresponding to the equation, was determined by H. S. Allen, H. D. Arnold, and others. For quartz spheres in water it is 85μ, and it can only be said generally that when values are obtained which are greater than the critical radius, the actual radius is consequently not greater than the calculated value. For more viscous liquids this critical value is correspondingly higher, and is generally dependent on the velocity of sinking.

A more exact derivation of the resistance equation was given by C. W. Oseen, who also extended the use of the equation to greater velocities by bringing in a new term.

According to him the resistance $w = 6\pi r\eta v\left(1 + \frac{3}{8}\frac{\sigma_1 r}{\eta}\left|v\right|\right)$, —instead of simply $6\pi r\eta v$—where $\left|v\right|$ is the absolute amount of the velocity.

As for the above hypotheses, it can, of course, not always be asserted that for the fall of a quantity of mineral particles in a watery depositino they are realized (with the exception, perhaps, of the first point), but the

deviations from the actual radius and the Stokes' equation can scarcely be so large that they exert any substantial influence on the character of the *distribution curve* derived on the basis of the Stokes' equation, research on which is the object of the present work.

It has also been alluded to several times from different sides that in consequence of the circumstance that we have to do it in a watery deposition with particles of very *different form*, the velocity of sedimentation, cannot possibly be used for calculation of the dimensions of particles.

All this is quite correct, if it is a question of accurate determination of the dimensions of the particles; but it is forgotten that the requirements with regard to accuracy in the determination of the size of particles of soil components are quite different than when we have to do with the strict validity of the equation taken physically. An error of 5—10 per cent. in the determination of size is, if it is a question of determination of the dimensions of soil grains, tolerably unimportant, since (for example) sizes of particles in the now customary international groups lie 1000 per cent. from one another (2 mm. to 0·2 mm., 0·2 to 0·02 mm., and so forth—see *Intern. Mitt. J. Bodenkunde*, **4**, 1, 1914).

If it is a question of grains of very different shape, it is, however, difficult to settle what we wish to be understood by dimensions of the same, and it is recommended to introduce the conception of *equivalent radius* of particles. Particles of the same equivalent radius perhaps correspond to E. Ramann's grains of equal hydraulic value. If we imagine that simultaneously with the particle under consideration a sphere of the same material moves through the liquid and the sphere is so constituted that its speed is equal to that of the particle, we can, by stating the radius of this shpere, get an idea of the size of the particle. The relation between the actual dimensions of the particle and the equivalent radius may be deducted hydrodynamically only for the case of a rotation ellipsoid—the equation for which is given.

It is consequently seen that the equivalent radius is different according to the *way of falling*, which can be made very perceptible particularly in disk—and rod—shaped particles.

Perhaps for this reason there is a tendency to declare every employment of elutriation analysis insufficient. If the sample were so small as to consist of only small particles, or if the height of fall were very small, this would also be correct. But here the fact is otherwise, for it is a question of a summation, which extends over a large quantity of particles of a determined order of size, and the single equivalent radius cannot be determined, but it must suffice to ascertain the mean equivalent radius of a definite fraction.

The probability can be equally great for one or the other way of falling, and since not every individual speed of the particle is measured, but the mean velocity, the calculated *mean equivalent radius* corresponds tolerably well with the *mean size of particle*. With small particles the way of falling by no means remains unchanged, but in consequence of molecular impact the particles are in an irregular rotary movement (Brownian movement) by which the resistance to movement changes continually. These rotary movements and turnings of the particles which cause now quicker, now slower fall, can be observed microscopically quite well, for example, in biotite particles.

For other cases, where the shape of the particles is not to be traced to the rotation ellipsoid, the relation between equivalent radius and the actual dimensions remains for the present unknown, but by specification of the equivalent radius of one particle or the mean equivalent radius of an approximately equal-grained fraction of soil-particles, a size can be defined which at least as far as the order of the size is concerned, does not deviate considerably from the actual dimensions of the soil-grains.

For illustration of the above, and to demonstrate the applicability of the equation of Stokes as well as the corrected equation of Oseen on sedimentation, the author calculated the equivalent radii from the times of

falling at 15°C., and compares them with the sizes of grain determined microscopically by A. Atterberg for particles of sand and clay:

Time of deposit for 10 cm. fall (Atterberg).	Velocity cms. per sec.	Equivalent radius calculated according to Stokes.	Equivalent radius calculated according to Oseen.	Radius of elutriated particles according to Atterberg.
5 sec.	2	78×10^{-4} cm.	101×10^{-4} cm.	100×10^{-4} cm.
50 ,,	0·2	$24{\cdot}8 \times 10^{-4}$,,	25×10^{-4} ,,	30×10^{-4} ,,
7′30″ ,,	$22{\cdot}2 \times 10^{-3}$	$8{\cdot}3 \times 10^{-4}$,,	$8{\cdot}3 \times 10^{-4}$,,	10×10^{-4} ,,
1 hour	$27{\cdot}78 \times 10^{-4}$	$2{\cdot}9 \times 10^{-4}$,,	$2{\cdot}9 \times 10^{-4}$,,	3×10^{-4} ,,
8 hours	$3{\cdot}472 \times 10^{-4}$	$1{\cdot}03 \times 10^{-4}$,,	$1{\cdot}03 \times 10^{-4}$,,	1×10^{-4} ,,
24 ,,	$1{\cdot}157 \times 10^{-4}$	597×10^{-7} ,,	597×10^{-7} ,,	—
100 ,,	$27{\cdot}78 \times 10^{-6}$	295×10^{-7} ,,	295×10^{-7} ,,	—

A. D. Hall has made a similar calculation in *J. Chem. Soc.*, **85**, 959, 1904. Swedish ground-deposits are probably built up mainly of little-changed mineral particles, and since the specific gravity of felspar is 2·56 to 2·75, of quartz 2·65, of the micas 2·8 to 3·2, the value 2·7 is used as mean specific gravity. The equation of Stokes may be given as

$$r = \sqrt{\frac{9}{2}\frac{v\,\eta}{(\sigma-\sigma_1)g}} = \sqrt{\frac{9}{2}\frac{\eta}{(\sigma-\sigma_1)g}}\sqrt{v} = K.\sqrt{v} \text{ or } v = Cr^2, \text{ where}$$

$C = 1/K_2$.

Putting η at 15°C. = 0·0114 in absolute mass; $(\sigma-\sigma_1) = 2{\cdot}7-1 = 1{\cdot}7$, and $g = 981$, the constant K has the value $5{\cdot}546 \times 10^{-3}$, and if v be expressed in cm./sec., the mean equivalent radius is obtained in cm.

In consideration of the difficulties in the experimental determination of the diameter of particles, the agreement between the observed value and that calculated from the Stokes' equation must be considered as sufficiently good. The Oseen equation gives, as was to be expected, the best values, but is too complicated to be employed in the following mathematical treatment.

In the constants, only η is strongly dependent on the temperature, and since (as already stated) the internal friction from 25° to 10°C. changes from 895×10^{-5} to 1307×10^{-5} (or about 46 per cent.), it is necessary in the calculation of the equivalent radius to have regard to temperature. Accordingly a table is given showing the dependence of the constants K and C on the temperature (from 10° to 25°C. in steps of 1°C.).

A discussion follows with some theoretical conclusions for sedimentation in unequal-grained systems. The author proceeds to describe, and explain the action of, his new recording apparatus for obtaining the curve of falling. Part of the apparatus consists of a cylinder with a movable plate hanging over the bottom; this plate can be considered as the bottom of a liquid cylinder of height equal to the distance from the plate to the surface of the liquid and of area equal to that of the plate. The plate can be weighed from time to time on a balance. For success in the tests it is necessary that (1) the plate shall be as near as possible to the actual bottom, so that no large space, empty as regards particles, shall arise under the plate, (2) the plate is at an approximately constant distance from the surface, (3) no mud shall collect between the plate, the wall and the real bottom of the vessel and inpair the freely suspending condition of the plate, (4) convection currents within the liquid of the cylinder be prevented as much as possible. The difficulties to be surmounted consist in satisfying the above requisites and yet to render possible an accurate determination of the weight of the plate and of the particles fallen thereon. It is not necessary to know the absolute weight in air, but suffices to weigh all weights in water and to relate with the total quantity of deposited particles in the finished test. The specific gravities of soil minerals do not vary so much that too great an error could arise from an arbitrarily taken mean specific gravity. As in the calculation of the equivalent radius, 2·7 was assumed as mean specific gravity.

The apparatus consists of three chief parts, the fall-cylinder, automatic balance, and recording apparatus, all of which are shown in illustrations. The fall-cylinder consists of a glass cylinder, 35 cm. high, and 138 mm. internal diameter. As the bottom of the cylinder is not quite plane, a strongly gilt brass bottom is cemented in. This does not fill up the whole bottom area of the cylinder, but is of plinth-like build and leaves a circular cavity free all round near the glass-wall. This is to prevent the possible interference with the freely suspended fall-plate by deposition of particles between it and the glass wall. The diameter of the circular area of the plinth is 98·6 mm., and that of the suspended plate 100 mm., the latter being slightly larger so that if not quite accurately centred no particles may accumulate on the plinth. The fall-plate is of German silver hammered out to a thickness of 0·38 mm. and strongly gilt; it is strengthened by a fold about 0·5 mm. high all round the edge, making the plate somewhat concave above. The plate is suspended on three gold threads from the scale-beam. The plate is made so thin that the change of specific gravity with progressive sedimentation and therefore the varying convection on the plate shall remain as small as possible.

All tests were carried out in a room for working at constant temperature, but in order to protect the fall-cylinder from small variations of temperature it was surrounded with a casing of felt one centimetre thick, and covered likewise with a felt-coated leaden lid. This lid is provided with small borings for the suspension threads and a glass syphon, the latter serving for the removal (after finishing the test) of the liquid with the very small particles not deposited. Adjusting screws enables the fall-cylinder and fall-plate to be regulated horizontally and vertically.

In the sedimentation of particles on the fall-plate the following takes place. It is assumed that on releasing the arrest at zero time equilibrium prevails; the plate is then suspended close above the plinth, the balance is in equilibrium and the beam is electrically insulated. But by sedimentation of particles on the plate, equilibrium is destroyed, and the plate begins to sink. But at the same time contact is made and the automatic feeding contrivance throws a small weight on the scale pan, whereby the balance is inclined to the other side and contact is broken. After a certain time the accumulation of sediment on the fall-plate causes contact to be made again, a second weight is automatically discharged, and so on. If now as here the arrest is so applied that the two positions right and left are very near to one another and to the zero position, the making of contact and lighting of lamp (which illuminates a scale) can be identified with equilibrium. By determination of the times of contact there is a possibility to continue measuring the velocity of accumulation. In consequence of the great damping of the system by the plate let down in water, there is no risk of the balance carrying out any oscillations whatever, whereby a double contact might take place. The times of equilibrium are fixed by the aid of the recording apparatus.

It is, of course, important that the filling in of the suspension should proceed as quickly as possible, and that the liquid when once poured in should come to rest. This latter point is the greatest source of error, and causes—particularly with coarser materials, where it is important that the recording apparatus should be set in motion as quickly as possible, variations in single tests with the same material. The checking of definite conditions of testing is here necessary, and the author describes an arrangement which he has found most appropriate. The method of conducting the whole testing operation is also described in detail, the apparatus working automatically after being fairly started. The author has had it in operation for 150 hours continuously without anything going wrong. It is not generally worth while to continue longer than this, because the particles still to be deposited (less than 0·3μ) fall so very slowly that a further 100 hours would make very little difference to the curve of distribution. At the end of the test the liquid is discharged by means of the syphon to the level of the plate, and after determining (with the ultramicroscope according to the Zsigmondy-

Siedentopf method) the number of particles in a known volume, the approximate value of the equivalent radius is calculated.

By the arrangement described it is possible to ascertain the quantity of particles sedimenting on the fall-plate as a function of the time. If different heights of fall are employed, they can all be converted to a normal height of 10 mm. From the whole data of the deposited particles, given as percentages, is obtained a fall-curve which is characteristic for each deposit. Numerous tables and curves are given in illustration, which are submitted as experimental proof of theoretical conclusions.

The author proceeds to discuss the mathematical analysis of the fall-curve, which is independent of the height of fall and of the absolute quantity of the substance deposited (assuming that P is expressed in fractions of $P_{inf.}$ the P values being percentages). The calculation of the distribution curve from the fall-curve is next considered, and finally there is a short note on the extension of the investigations on sedimentation in more viscous liquids (produced from glycerine and water).

PRELIMINARY TREATMENT OF SAMPLES OF SOIL, ETC., FOR MECHANICAL ANALYSIS.—Sven Odén (*Bull. Geol. Inst. Univ. Upsala*, **16**, 125, 1919). An account of preliminary tests, with results and discussion thereof.

In the normal method of treatment, the moist clay is carefully triturated in ammonia water by degrees with a stiff pencil (painter's brush), whereby the *smallest particles* are completely liberated; the larger aggregates are then elutriated or (better) centrifuged, and afterwards undergo a second treatment with the pencil. Then it is mixed with ammonia to about $0{\cdot}01n$ and shaken on the machine, this having particularly the effect of loosening the coarser aggregates or secondary particles. The earlier treatment affects specially the loosening of the smaller particles. The shaking with ammonia is here less important in itself, but aims only at a good mixing of the suspension. The most essential is the influence of the ammonia, which is effective in three respects, namely, by (1) strengthening of the negative charge of the clay particles, by which the particles exert a repelling action on (one) another and coagulation is prevented, (2) loosening of such aggregates in which humic acid functions as cement between the particles, the humic acid being dissolved as ammonium humate, (3) the increase of alkalinity of the dispersion medium, by which according to the law of mass action dissociation of the calcium ions is repressed and coagulation by calcium cat-ions is prevented.

As to the strength of the added ammonia, generally so much is added that a faint smell of ammonia is noticeable, about $0{\cdot}004$ to $0{\cdot}01n$; clays containing humus or much lime require more. No disadvantages appear, even with much greater addition of ammonia up to $0.1n$, for coagulation by ammonia first arises at very high concentration (2—3 normal). Especially with clays very rich in lime is the use of ammonia indispensable, because otherwise the suspension is separated in flakes in the fall-cylinder by calcium ions. Sometimes such a coagulation can happen to a clay very rich in salts ($NaCl$, KCl, and $MgCl_2$).

The recording must then either be carried out with a small sample of clay and correspondingly diluted suspension or the electrolytes present removed by dialysis, which is very briefly explained.

ANCYLUS CLAY.—Sven Odén and A. Reuterskiöld (*Bull. Geol. Inst. Univ. Upsala*, **16**, 135, 1919). An illustrated article dealing in considerable detail with the geology and conditions of deposition, mechanical composition, chemical composition, and the action of hydrochloric acid on certain fresh-water deposits.

SILICA PRODUCTS.—A. Bigot (*Chem. Ind.*, **1**, 194T=712, 1918). See TRANS., **17**, 259, 1918, and **18**, 165, 1919.

SILLIMANITE REFRACTORIES.—A. Malinovszky (*J. Amer. Cer. Soc.* **3**, 40, 1920). An illustrated account of the malinite process, which re-

sembles the Lecesne process for producing corindite (fused bauxite). See also TRANS., **19**, 140, 1920.

SILICEOUS SAGGAR MIXTURES.—M. R. Hornung (*J. Amer. Cer. Soc.*, **3**, 67, 1920). An account of an investigation of mixtures of clay and free silica (chert and quartzite) for making saggars to carry heavy loads up to 1375°C., and to resist rapid temperature changes.

The inferences drawn from the results obtained are as follows: Chert gives better results than quartzite, and finer ground siliceous materials are more advantageous than coarser ones. Previous calcination of the chert or quartzite improves the saggar bodies with reference to heating and cooling treatment, whilst the introduction of calcined flint clay improves their general character and counteracts their tendency to spall. A neutral condition of no shrinkage or expansion in firing requires 60 to 65 per cent. of raw chert or quartzite. It appears that saggars and other products containing siliceous refractories (especially chert) can be made to combine excellent resistance to load conditions and permanence of volume with satisfactory behaviour under conditions of heating and cooling. A mixture of 50 per cent. raw clays, 20 per cent. calcined flint clay, and 30 per cent. chert (raw or calcined, and passing a 40-mesh sieve) is suggested. Half the raw clays consisted of equal proportions of two ball clays and a third bond clay, the other half being two kaolins in equal proportions.

LOAD BEHAVIOUR OF ALUMINOUS REFRACTORIES.—A. V. Bleininger (*J. Amer. Cer. Soc.*, **3**, 155, 1920). Relates to mixtures of high grade, calcined Pennsylvania flint clay and artificial sillimanite, the latter being prepared from 71·6 per cent. North Carolina kaolin and 28·4 per cent. anhydrous alumina (a pure grade of bauxite). The thoroughly ground sillimanite mixture was fired to cone 20.

The plastic constitutent was either North Carolina kaolin alone, or half kaolin and half fire clay, the latter being the usual bond clay in Pennsylvanian flint clay bricks.

The mixtures, five in all, were made into standard size bricks, one mixture by the soft-mud process, and the rest by dry-pressing. The bricks were fired to cone 14 or 16, in the case of one mixture to both.

The results indicate that refractories high in alumina can be produced which resist load conditions and are practically constant in volume. The main point is to fire at a sufficiently high temperature; thus with the same mixture fired at cone 14 and cone 16 respectively the contraction in the load test (50 lb. per sq. inch at 1400°C.) was 2·80 and 0·84 per cent.

Synthetic sillimanite requires a high temperature for its formation, and microscopic examination readily determines whether it is formed or not. The failure of certain bauxite refractories in use is undoubtedly due to non-observance of the requirements for practical permanence of volume at furnace heats—sufficiently high temperature for both the calcination of the aluminous ore and the firing of the bricks. The proper temperature can be established for every mixture, and may be lowered by adding a little flux, such as boric acid. It is also essential to grind together intimately the kaolin and alumina (or bauxite) before calcination. The moulding of the bricks by dry-pressing helps to reduce both the firing contraction and the deformation under load conditions. It is believed that synthetic sillimanite produced by proper heat treatment can be developed to form a very useful type of refractory for severe heat conditions.

MAGNESITE REFRACTORIES.—J. S. McDowell and R. M. Howe (*J. Amer. Cer. Soc.*, **3**, 185, 1920). A general survey of the occurrence of the raw materials (from various countries) and of the preparation and properties of magnesite and refractories made from it. Numerous references are given, and a copious bibliography is appended. Some original data are included.

The names in use for the different magnesite products are somewhat confusing, the following representing common usage:

Magnesite: (1) The mineral $MgCO_3$, which is the raw material of the magnesite industry; (2) a term applied to various products obtained from

the preceding, as "dead-burned" and "plastic" magnesite, magnesite bricks, etc.

Plastic magnesite or caustic burned magnesite: The product obtained on calcining crude magnesite at a comparatively low temperature, and which contains about 2 per cent. to 5 per cent. CO_2; it is also called calcined magnesite.

Calcined magnesite: (1) Magnesite which has been calcined at any temperature, including both caustic and dead-burned; (2) a product intermediate between caustic and dead-burned magnesite, *i.e.*, magnesite which has been calcined but not sintered, and in which the CO_2 content is below 2 per cent. (usually about 1 per cent.).

Dead-burned magnesite or dead-burned magnesia: A sintered product obtained by calcining magnesite at a high temperature; it usually contains less than 0·5 per cent. CO_2, and almost invariably contains 4·5 to 8 per cent. Fe_2O_3, either naturally or by additions of iron ore during the treatment.

Electrically Shrunk magnesite: Magnesite calcined in the electric furnace to effect complete shrinkage; usually nearly pure.

Magnesia or magnesite bricks: Bricks consisting essentially of MgO, generally containing 4·5 to 8 per cent. Fe_2O_3.

Magnesia: (1) Pure magnesium oxide; (2) a term applied synonymously with "magnesite" to bricks, dead-burned material, etc.; (3) applied to certain magnesite products low in impurities and high in MgO, as magnesia crucibles, electrically shrunk or fused magnesia, etc.; (4) precipitated or basic carbonate of magnesia.

Basic carbonate of magnesia: A light powdery material prepared either by boiling a solution of acid magnesium carbonate, or by double decomposition of a soluble magnesium salt and a soluble carbonate. The commercial product varies somewhat in composition, but is generally given as $MgCO_3.Mg(OH)_2+3H_2O$, the same as hydromagnesite.

The temperature at which dead-burned magnesite (as defined above) can be formed depends on the texture and composition of the crude magnesite. A magnesite high in iron oxide, as the Styrian, will shrink and frit together at 1450° to 1500°C., whilst a temperature of 1600° to 1700°C. or higher is required for one low in iron oxide and other impurities. Hence for most refractory purposes a small percentage of iron oxide is considered necessary for satisfactory production of dead-burned magnesite, which will not shrink further at furnace temperatures, and which will sinter to form a well bonded furnace hearth at working temperatures. Iron oxide (to make up 4·5 to 8 per cent.) may be added as iron ore, which with the magnesite should be finely ground and intimately mixed before calcination.

Analyses are given of various magnesites. The making of small magnesia crucibles is described. As regards the making of magnesia bricks, it is not customary to use bonding material in America; caustic magnesia was formerly in general use for this purpose, but whilst it facilitated moulding it was subject to shrinkage at high temperatures. In Europe, serpentine has been used to bond the amorphous magnesite of Greece, and clay up to 15 per cent. has also been tried, but it decreased the refractoriness too much. Temporary bonds, such as tar, molasses, and dextrine, are more or less used in Europe, though not always. Ground dead-burned magnesite was moistened with 4 to 5 per cent. of water (sometimes though not usually with also dextrine or similar binder), and after mixing—and sometimes standing for 2 days to 3 weeks—it was moulded in a hydraulic press. The green bricks were dried slowly and fired at a maximum temperature (maintained for 24 hours) of usually about cone 18, though some German manufacturers heated to cone 26. It has been stated that bricks burned to cone 30 to 34 shrink so much that they can be used in furnace arches.

In the United States, the ground dead-burned magnesite is well mixed in a wet pan with a little water, and the bricks are generally moulded in a power press. The freshly made green bricks are extremely fragile, but after drying in tunnel driers they are usually tough and hard. As they are easily deformed during firing they are boxed in with silica bricks so that there is

practically no load on them. The firing takes place in rectangular down-draught kilns, and cooling is slow. The firing shrinkage amounts to about 3/32 to ⅛ inch per foot. Brief reference is made to the "metalkase bricks," consisting of round or square soft steel containers, open at the ends, packed with dead-burned magnesite.

The properties of caustic, dead-burned, and fused magnesia, are discussed at some length, including colour, texture, fusion point, specific heat, microscopic structure, specific gravity, shrinkage, chemical composition, crushing strength of magnesia-silica mixtures at high temperatures, electrical resistivity, thermal expansion, hydration and slaking, action of carbon on magnesia at high temperature, action of phosphorus and silicon at high temperatures upon dead-burned magnesite, etc. The properties of magnesia bricks are also considered, including specific gravity, crushing strength, specific heat, thermal conductivity, electrical resistivity, thermal expansion with and without load, and chemical action between magnesia and fireclay or silica bricks. Microscopic studies take up one section of the article.

The bibliography begins with a paper (by J. Rumpf) dated 1873, followed by others in 1882, 1885 to 1887, 1890, 1892, 1893, 1899, 1900, 1903, 1905 to 1919.

ELUTRIATION TESTS ON AMERICAN KAOLINS.—H. G. Schurecht (*J. Amer. Cer. Soc.*, **3**, 355, 1920). Many physical properties of clays, such as plasticity, dry strength and shrinkage, are to a limited degree functions of the size of grain, which also influences ease of vitrification and fusion. Material coarser than 0·074 mm. can easily be separated into different sizes by wet screening, the sizes specified being greater than 20 mesh, 20-65 mesh, 65-100 mesh, 100-200 mesh. (The sizes of opening in the standard Tyler screens used—20, 65, 100, and 200 mesh—were 0·833, 0·208, 0·147, and 0·074 mm., or 0·0328, 0·0082, 0·0038, and 0·0029 inch respectively). The elutriation analysis was carried out with a modified Schulze apparatus figured.

The elutriation of kaolins should be carried on with distilled water instead of tap water, as the soluble salts in tap water cause the clay particles to coagulate and settle as larger grains. Results agree better when the residues are stirred at intervals.

English ball clay contains an extremely high percentage of fine material, 98·55 per cent. being carried away by a flow of 0·0197 mm. per second. Only 40·75 per cent. of English kaolin was carried off by this velocity. It is evident that the greater plasticy and bonding strength of ball clays, as compared with kaolins, is due largely to their finer grains.

THE PROPERTIES OF SOME STONEWARE CLAYS.—H. G. Schurecht (Tech. Paper, 233, *U.S. Bur. of Mines*, 1920). The paper gives the results of investigations, begun in June, 1917, into the possible use of some Ohio and Pennsylvania stoneware clays. The studies were commenced mainly as the result of the marked increase in the demand for chemical stoneware during the war. Eleven samples, designated A to K, were examined, and their place of origin, together with the geological section of each mine, is indicated.

For the investigation, test pieces were moulded from seven bodies which were prepared from each of the clays. The bodies were as follows:

Body 1. Run-of-mine clay ground dry to pass a 20-mesh sieve.

Body 2. Clay washed through a 150-mesh sieve.

Body 3. Residue from washing, ground to pass a 150-mesh and added to the washed clay.

Body 4.—95% washed clay (150-mesh) and 5% feldspar.

Body 5. 90% washed clay (150-mesh) and 10% feldspar.

Body 6. 95% washed clay (150-mesh) and 10% feldspar plus 0·16% $CaCO_3$.

Body 7. 95% washed clay (150-mesh) and 5% feldspar plus 6·1% $CaCO_3$, The two calcite-orthoclase eutectics were used as a guide in adding the $CaCO_3$. (*Trans. Amer. Cer. Soc.* **18**, 577-618, 1916.)

The drying shrinkage, tempering water, shrinkage water, pore water, rate of slaking in water, and the transverse strengths in the green condition were determined for each body.

The softening points of the clays were compared to those of Orton pyrometric cones. The apparent porosities and volume shrinkages of the briquets were determined after firing to the different temperatures.

The warping test consisted in applying a load on the centre of the test bar, which rested on two knife-edges placed 6 inches apart. A three pound weight was applied to the bars having a 1 by 1 inch cross section, corrections in weight being made for those having a smaller cross section. The deformation was expressed as the percentage of warpage in terms of the length of the span.

Transverse-strength tests of the burned test bars were made after heating 5 times to 600°C. and quenching in water at 18C°. after each heating. The percentage decrease in strength gives a rough indication of the resistance of the fired bodies to temperature changes.

To measure volume shrinkage, a volumeter operating on the principle of the pycnometer was designed by the writer, in order to overcome some of the objections to the Seger apparatus. The advantages claimed for this new device as compared with the Seger volumeter are:

1. The pycnometer can be operated two to five times more quickly.
2. The apparatus is comparatively accurate, volumes can be determined to within 0·01 to 0·05 c.c.
3. The error due to the lodging of grit or clay in the joint of the stopper is less because the stopper is smaller.
4. Less chance of error from air bubbles.
5. The apparatus is less cumbersome and not so easily broken.
6. The device is less expensive, simple to construct, easy to clean, and occupies less space.

The data obtained with the different clays and bodies is tabulated in detail and illustrated by curves. With few exceptions, screening the clays through a 150-mesh improves the raw and burned strengths, increases the dry porosity, lowers the vitrification temperature, widens the vitrification range, decreases the burned porosity, increases the burning shrinkage, and increases the density in the burned condition.

In some of the clays the residue from screening, if ground and screened through a 150-mesh, may be added to the washed clay with good results. The addition of feldspar alone, or with a small percentage of calcium carbonate, decreases the vitrification temperature. With a larger percentage (6·1%) of $CaCO_3$ the body is more porous at lower temperatures, the vitrification temperature is raised, and, in general, the vitrification range is decreased. The maximum strength of all clays tested was developed by burning to cone 8.

There appeared to be no relation between softening temperature and resistance to warpage under load at low temperatures—some of the most refractory clays failing before the less refractory ones.

There was a decided decrease in mechanical strength while the clays were being burned above cone 1. In one clay the modulus of rupture was 270 in the dry state, but decreased to 27 at cone 4, although it was a No. 1 fire clay.

The run-of-mine clay screened through a 20-mesh sieve seemed to be more resistent to the quenching treatment when burned than the same clay screened through a 150-mesh sieve. When bodies prepared from these clays are burned above cone 8 they are not as resistant to sudden temp. changes as those burned to cone 6 or 8.

THE SHRINKAGE PROCESS IN CERAMIC BODIES.—W. Pukall (*Sprech.*, **52**, 429—31, 443—5, 1919). The author lays no claim to exhaustive treatment of the subject, his object being mainly to stimulate further research in the important matter of shrinkage. He points out that the initial moisture content of the body exerts a decided influence in promoting shrinkage.

Plastic bodies tend, in general, to contract towards their centres of gravity. This applies both to solid, and, in a slightly smaller degree, to hollow forms, whether spherical, cylindical, rectangular, etc. If two or more spheres, of the same or different sizes but made of the same body, are placed together and made to adhere lightly at their points of contact, each sphere tends to contract towards its centre during firing. But movement also takes place in another direction. If, for instance, one of the spheres remains stationary, the others will be drawn towards it, provided that the friction between the various spheres and their support is overcome. If this latter counteracting force is the stronger, the spheres will naturally break asunder. A large sphere may also be considered as built up of innumerable minute spheres which behave in a similar manner. Although their main tendency is to shrink towards the stationary centre of the whole mass, they must also be subject to a pull in other directions, as, for instance, in the direction of all the layers parallel to the circumference. The ideal condition is obtained when the common pull towards the centre just balances these counteracting forces, *i.e.*, when the particles are distributed with absolute uniformity throughout the mass. The same applies to hemispheres, sectors and sections.

With regard to the elasticity of clay bodies, the writer lays stress on the fact that a body cannot be stretched without forcibly drawing the mass-particles away from each other. It follows, therefore, that the shrinkage of an extenuated portion will be greater than that of the normal body.

Applying the above to the manufacture of a plate, and similar articles, consisting of a rim, which is a truncated hollow sphere, a cylindrical foot, and a flat bottom, it is pointed out that the rim is often formed in a manner which leaves it in a highly extenuated condition. Further, the cylindrical foot, which is thicker than the other portions, will have a greater shrinkage. These two factors will cause warping, etc. during firing.

In casting, it is important that the plaster forming the mould, or moulds, should be of uniform porosity, otherwise more body will be absorbed in a given time by one portion of the mould than by the remainder. The corresponding portion of the cast object will then shrink more than the other parts.

III.—THE COMPOUNDING & PREPARATION OF CLAYS AND BODIES.

BRICKS OF COMPRESSED EARTH.—(*Cer.*, **23**, 19, 1920). A short account of experiments carried out to meet the urgent requirements of the devastated areas in France. Good results have been obtained with ordinary earth containing 5 to 8% of clay, subjected to a pressure of from 200 to 400 kilogramms to the sq. c/m. The bricks if well pressed, should support a pressure of not less than 50 kgm. to the sq. c/m. Shrinkage, due to drying, should not exceed 1%, and this without cracking. Special precaution must, of course, be taken against the action of water, *e.g.*, foundations of masonry, protective coatings of plaster, etc. A trial structure, built of inferior bricks and without protective coatings, showed evidence of deterioration only on the western side. Waterproof paint is now being experimented with, and excellent results are expected. These bricks are not intended for general use, but only for rural areas, for farms, stables, etc. Their advantages are obvious.

PATENT BRICKS.—(*Cer.*, **23**, 5, 1920). An article dealing with various types of patent bricks, for making ceilings without metallic supports, for building walls of all descriptions without mortar or cement. The ceiling bricks are tongued and grooved to provide rigidity. A method of constructing a truss girder by means of clamping bricks is discussed. Roofing

is simplified by the use of a special brick which dispenses with laths, tiles, slates, etc. A paving brick for stables, etc., is illustrated, which provides effective drainage by means of horizontal channels in the bricks themselves.

DOMESTIC STONEWARE.—M. E. Greber (*Cer.*, **23**, 1920). A general survey of the French industry, in particular that carried on in central France. The manufacture of culinary pottery of glazed earthenware is also undertaken paralled with stoneware. Natural earths and clays are used, containing the necessary proportion of scouring and fluxing ingredients. They are usually grey in colour, sometimes yellowish or creamy. Their texture may be very fine or relatively sandy. Washing and cleaning is resorted to in the case of the fine white qualities.

The majority of the articles being small and circular in form, they are usually turned by hand. Articles manufactured include: (1) bowls—in about 15 sizes, with a capacity varying from 02·0 to 30 litres, made with large rims to prevent damage to the interior glaze when the bowls are placed one inside the other. (2) Boxes with lids—made in two forms, straight and pear shaped. Moulds for the latter are in two pieces, for the former they may be in one or two pieces. (3) Small pitchers—hitherto no attempt has been made to manufacture these articles except by turning. Moulding and casting methods are discussed. (4) Hot-water bottles and miscellaneous articles. These are turned mechanically or cast.

SLAG BRICKS.—R. Malfait (*Rev. mat. construction et trav. publ.*, **123**, 335—6, 1919). Granulated slag contains an excessive amount of water, some very porous slags as much as 60%. Storing under cover for a month or more will reduce the water content to 6—12%. The slag can then be ground, the water still remaining effects the hydration of the Ca Silicate and thus forms the chief binding agent. Any surplus water tends to dissolve the lime and disintegrate the bricks. If subjected to the action of salt water, the most important factor is porosity, the least porous bricks being the most resistant. The addition of colloidal gels such as glue, tannin, etc., gives greater durability. The use of pitch as a binder gives still better results. Bricks made of ground slag mixed with finely ground chalk, when immersed for eight days, gave up 25 g. to dist. water, 20 g. to a saturated solution of $CaSo_4$ (0·2%), and 15 g. to a 1% solution of a mixture of Na, Mg, and Ca Sulphates. 100 gr. of powdered slag brick lost 3·285 in dist. water and 2·560 gr. in $CaSo_4$ solution, and gained 2·195 gr. in a solution of mixed sulphates. After immersion for one month in a 3% solution of NaCl, slag bricks lost from six to eight times as much as in dist. water. Though much less porous than clay bricks, slag bricks should not usually be employed in situations where they are in contact with sea-water.

PREVENTABLE DEFECTS IN REFRACTORY BRICKS.—C. E. Nesbitt and M. L. Bell (*Proc. Amer. Soc. Test. Mat.*, **19**, 619—39, 1919). Certain manufacturing defects greatly shorten the life of refractory constructions under severe conditions in the iron and steel industry. Defects in moulding, setting, and burning should be caught in visual inspection. The crushing strength, hot, of SiO_2 brick was found to be lowered by slag penetration from 1451 lbs. sq. in. for slag free brick to 775 for slag-penetrated brick. To overcome this a dense brick is advocated. Power-pressed SiO_2 brick was found to have 25% lower penetration by heating-furnace slag than hand moulded brick. It is claimed that 80% of the defective brick now used can be detected by careful visual inspection.

MANUFACTURING SLAG-LIME BRICK.—Anon. (*Brick*, **55**, 858, Nov., 1919). A short description of a new process installed at an Illinois Plant. The slag is received in a fairly fine condition from the steel works. Definite quantities of this slag mixed with fixed amounts of lime (ground, and fairly pure) are placed in a large steel barrel holding sufficient material for 2,500 bricks. To obtain a thorough mixture, steam is projected into the barrel, which is made to rotate for about an hour. The material is then

passed through a machine to remove any lumps that may have been formed. It is then introduced into a press containing a number of moulds and at the proper moment pressure equivalent to 400 tons is exerted. The table of the press revolves continuously and the machine works automatically. From the press, the bricks are loaded on trucks, which are placed in long iron boilers. Each truck holds 1,000 bricks and each boiler 17 trucks. When full, the boiler is sealed and steam at a definite pressure is introduced. This hardens the brick and requires about eight hours. The bricks are then ready for use. Crushing strength of bricks—2,977 lbs. per sq. in. Absorbtion (water) 8·29% in 48 hours. The bricks fuse to a liquid at 2450°F. Roofing tiles, with artificial colouring matter added, are also manufactured.

HIGH-TENSION INSULATOR PORCELAIN.—W. Peaslee (*J. Amer. Inst. Elec., Eng.*, **39**, 445, 1920). Mechanical strength of porcelain is of the utmost importance. Ordinary porcelain made of clay, flint and felspar has a maximum strength of 40,000 lbs. per sq. in. for compression and 1,500 lbs. per sq. in. for tension. Certain types of porcelain are now available whose strength runs up to 65,000 lbs. per sq. in. in compression and 12,500 lbs. per sq. in. in tension. Material for high tension insulators must be able to stand alternate immersion in boiling and freezing water. Non-porous porcelain has been produced, according to the author, under manufacturing conditions. Porosity caused in apparently perfect units may be due to piezo-electiric effect.

BREAKAGE IN HIGH TENSION INSULATORS. (*Ker. Rund.*, **28**, 1—2, 1920). A short account of investigations carried out by E. O. Meyer, into the causes of the frequent cracking of insulators. Various types of insulators, in one piece and in two and three parts, were under observation under different conditions. Careful investigations led to the conclusion that mechanical and external factors, such as the hammering of the wires against parts of the insulators during rough weather, and electrical influences must be rejected as being the cause of the trouble (ibid., 11—12). Sharp edges and corners on the insulators were found to favour the appearance of cracks. The quality of the porcelain was not considered a deciding factor, though faulty burning, mixing of two raw materials of unequal di-electric properties, etc. might no doubt account for cracking and splitting in isolated instances. (The material under observation was delivered by different firms over a period of several years.)

Experiments were conducted to test the effect of thermal influences, such as sudden change of temperature, etc., on the porcelain, and the conclusion is reached that the cement which binds the various parts of the insulator together was responsible for the cracking. The co-ef. of expansion of the cement is three times greater than that of porcelain. The splitting does not make its appearance until after two to three years, since cement requires that length of time to set and become completely inelastic. The chief cause of the cracking of the insulators is thus concluded to be the excessive and irregular thickness in the layers of cement.

PROBLEMS OF STONEWARE MANUFACTURE IN THE FUTURE.—(*Ker. Rund.*, **28**, 29—30, and 48—49, 1920). A short survey of conditions in Germany. Emphasis is laid on the great diversity in the quality of German clays and sands, as compared with English supplies, and the consequent necessity of specifying not only the nature, but also the source of raw materials used in any given mixture.

INSULATOR PORCELAIN.—(*Chem. and Met. Eng.*, **23**, 301, 1920). Christian Dantsize discovered that the use of a stable refractory, such as an oxide of zirconium, titanium, aluminium, magnesium, glucinum or thorium, in place of silica improves the insulating properties of porcelain. A typical porcelain, consisting of 45 parts clay, 35 parts felspar and 15 parts flint, if heated to 800°C. and then plunged into water, becomes highly fragile. If the silica in such a porcelain is replaced by a refractory metallic oxide, similar treatment will not affect its mechanical strength. At high temperatures the electrical resistance of zirconia porcelain is greater than that of

ordinary porcelain. The former is also less porous than the latter.

ARTIFICIAL GRAPHITE.—(*Chem. and Met. Eng.*, **23**, 196, 1920). The Acheson Graphite Co., at Niagara Falls, N.Y., utilises the electric power generated at the falls to manufacture graphite from anthracite coal or petroleum coke. The product is used mainly in lubricants, paints, foundry facing, etc. It is also very suitable for graphite electrodes. The output in 1919 was over eight million pounds.

HOW TO MAKE THE BEST SILICA BRICK.—H. le Chatelier and B. Bogitch (*Brick*, **54**, 686—90, 1919). Firing is the most important factor, while the nature of the quartz and fluxes, and the proportion of impalpable material determine the resistive properties. A well-illustrated article by the noted French experts.

MAGNESIA STONEWARE.—(*Tonind. Ztg.*, **31**, 399, 1907). If magnesia, usually in the form of dolomite, is added to the body to replace some of the lime, the ware becomes less susceptible to pressure and shock. According to A. Richards, an Italian stoneware consists of:—

35 — 45%	Clay.
35 — 45%	Dolomite.
10 — 15%	Sand.

If dolomite is not available the carbonates of lime and magnesia may be used. Giobertite, found on the island of Elba, and near Castella Monte Canavese, in Tuscany, is also employed. Its composition is as follows:—

	Elba	Castella Monte Canavese
Silica	13·8%	13·2%
Clay	5·1% }	0·7%
Iron oxide	1·6% }	
Lime	1·1%	1·1%
Magnesia	34·1%	40·5%
Carbon dioxide ..	44·3%	44·5%

The above-mentioned Italian stoneware body follows the formula:

$$\left.\begin{array}{l} 0{\cdot}14 \text{ — } 0{\cdot}34\ CaO \\ 0{\cdot}86 \text{ — } 0{\cdot}66\ MgO \end{array}\right\}\ 0{\cdot}27\ Al_2O_3\ (+Fe_2O_3).\quad 1{\cdot}3\ SiO_2.$$

The temperature for the biscuit oven ranges between cone 08 to 03; firing is completed between cones 010 and 05. Shrinkage varies from 2 to 3%. Both lead and leadless glazes are used.

DECOLOURISATION OF PORCELAIN.—A. Novak (*Sprech.*, **52**, 104, 1919). An article dealing with the problem of improving the German kaolins. The addition of a small percentage of potash (fritted with quartz, felspar and a little kaolin) is said to give satisfactory results.

MAGNESIA-CRYOLITE PORCELAIN.—T. H. Möhrenbach (*Tonind. Ztg.*, **33**, 187, 1909). The addition of Magnesia to a porcelain body has the effect of giving a greater, but more regular shrinkage. An artificial aluminosilicate of magnesia—$MgO.Al_2O_3.6SiO_2$—was made by mixing 84 parts by weight of Magnesite, 258 parts Zettlitz Kaolin, and 240 parts Quartz. About 3·5% of this was added to the body in place of Felspar, so that the Magnesia porcelain body consisted of: 53 parts by weight of clay, 23·5 parts Felspar, 20 parts Quartz and 3·5 parts Magnesia spar. The clay contained 35 parts by weight of Zettlitz Kaolin and 20 parts china clay, which together contained 2 parts of spar. Accordingly, 21·5 parts of Norwegian spar and 20 parts burned quartz, together with the 3·5 parts Magnesia spar, were added. The magnesia spar content corresponds to 0·5% $MgCO_3$ in the mass. Of this, 0·25 was then replaced by the corresponding weight of sodium spar, made artificially from cryolite. The final composition of the body was then: 35 parts Zettlitz clay, 20 parts china clay (=53 parts), 21·85 parts Felspar, 20 parts Quartz, 1·75 parts artificial magnesia spar, 1·4 parts artificial sodium spar. Spars and quartzes which burn pure white naturally give the

whitest porcelain. A lime glaze proved to give the best results for this type of porcelain.

TERRA COTTA SLIPS.—H. Wilson (*J. Amer. Cer. Soc.*, **3**, 114, 1920). American terra cotta falls into three general classes, high-fired (cones 6-7), medium fired (cones 3—4), and low-fired (below cone 3, usually cones 01—3). The original vitrified coatings—as distinguished from glaze coatings—were composed of natural slip clays and were usually buff, brown, or red. These natural clay slips, blended with more or less fluxing material, are still largely used for the darker vitrified coatings. For the present high-fired terra cotta, vitreous ink-proof white slips can be produced with mixtures of felspar, ball clay, kaolin, flint, and Cornish stone as a base. But for the lower temperatures (especially below cone 4) fritted fluxes are commonly added. For glaze coatings, modified Bristol glazes have served above cone 4, fritted glazes being used below that temperature. Some salt glazing has been done.

The following general conclusions were arrived at. The physical condition of the body upon which vitrified slips and glazes are sprayed is very important for producing perfect surfaces. The maximum size of grog grains and the proportioning of the grog sizes, the methods of pressing, finishing, and spraying are all of great importance.

The composition of the slip needs thorough investigation, and it is suggested that the shape of the individual particles should also be investigated for the production of unbroken coatings. This includes the study of the magnesia and magnesia-alumina silicates as represented by asbestos, steatite, and the minerals of the general mica division. Chlorite mica (10 to 15 per cent.) added to a slip consisting of flint, Cornish stone, and English china and ball clays, decreased the absorption so that the slips were practically ink-proof, decreased the cracking to a minimum without blistering, and darkened the colour. The fluxing effect of two or three per cent. of asbestos in slip seemed as great as that of 10 to 15 per cent. chlorite mica. It was also found that 3 per cent. asbestos in the glaze gave good results without an underslip.

WHITE WARE POTTERY.—A. V. Bleininger and W. W. McDanel (*J. Amer. Cer. Soc.*, **3**, 134, 1920). A report on an investigation to ascertain whether satisfactory white ware could be manufactured from exclusively American materials. The conclusion was that good white ware pottery can be produced from home materials, but the output of the American mines, is not sufficient to justify the elimination of English china clay, which is supplied in uniform quality and at competitive prices.

EFFECT OF METHOD OF PREPARATION ON THE VISCOSITY OF A CASTING SLIP.—V. S. Schory (*J. Amer. Cer. Soc.*, **3**, 286, 1920). The properties of a casting slip made from felspar, flint, china clay, and ball clay depend chiefly on the ratio of non-plastic to plastic materials, the relative proportions of ball clays and china clays, the properties of each ball clay and china clay and the percentage of each clay used, the impurities in the clays and the substances added, the percentage and relative amounts of alkaline reagents used in the slip, the percentage of water, the method of preparing the slip, and its age and temperature.

The properties of a casting slip which it is desirable to keep constant are the specific gravity, viscosity, rate of casting, firmness of the cast, cleanness of drainage of surplus slip from the cast, strength retained by the cast, hardening and drying of the cast in the mould, and low shrinkage of the cast during the early stages of hardening and drying.

The viscosity of a given slip depends on the percentage of alkaline reagents used, the water content, and the method of preparing the slip. It is not feasible to adjust the viscosity of a slip by changing the percentage of alkaline reagents used, as there is only a small margin of variation without incurring excessive deflocculation or insufficient deflocculation. A moderate variation in the water content may be used to regulate the viscosity of the slip, without greatly affecting its casting properties. A slip may be pre-

pared having any desired water content and viscosity, and still be a failure when used in the casting shop.

If the composition of the body does not vary and the water content of the slip is kept uniform, the viscosity becomes a measure of the degree of deflocculation of the slip, and enables the operator to bring each charge of slip approximately to a standard condition.

The results of the author's experiments (with two different bodies) showed lowest viscosity when sodium carbonate was added first and sodium silicate later, highest viscosity when both were added together, and intermediate when sodium silicate was added early and sodium carbonate later. The slips prepared from filter-pressed clay showed lower viscosity than those made from dry clay. The specific gravity of the slips was 1·75, but in the case of some prepared by grinding in pebble mills the specific gravity was 1·72. The amounts of anhydrous alkaline reagents used were for a special body (of composition given) 0·027 per cent. sodium carbonate and 0·036 per cent. sodium silicate, and for a commercial heavy sanitary earthenware body 0·057 sodium carbonate and 0·076 sodium silicate, the percentages being reckoned on the dry weight of the body. Blunged slips with the lowest content of alkaline reagents gave the firmest casts, but this was not invariably the case with slips prepared by grinding.

BARIUM HYDRATE IN TERRA COTTA BODIES.—M. E. Gates (*J. Amer. Cer. Soc.*, **3**, 313, 1920). An account of a satisfactory method of using barium hydrate (instead of barium carbonate), with illustration showing the apparatus. The use of barium hydrate is advantageous because being more soluble than barium carbonate it more easily comes in contact with soluble salts than the carbonate, and therefore is more economical.

TERRA COTTA BODIES.—R. L. Clare and D. F. Albery (*J. Amer. Cer. Soc.*, **3**, 384, 1920). Relates to the effect of variation of the size of the grog. In the unburned state the coarse mixture reduced the drying shrinkage, increased the difficulties in pressing and finishing, and did not dry straight. The medium mixture pressed well, finished fairly easily, and dried straight without cracking. The fine mixture pressed well, finished easily, increased the drying shrinkage, and showed a decided tendency to crack in drying.

In the burned state, the coarse mixture was weak, showed no warping or cracking, comparatively low absorption, low fire shrinkage, and very poor glaze covering. The medium mixture had good strength, very slight warping and cracking, and good glaze covering. The fine mixture was the strongest, showed considerable warping and cracking, the lowest absorption, and the best glaze covering.

For terra cotta of uniform physical properties, the grog size must be controlled, and this can only be done by having grog specially prepared, and ground under stated conditions.

PUG MILL CONTROL.—H. Spurrier (*J. Amer. Cer. Soc.*, **3**, 388, 1920). A method of ascertaining the pressure at different points of the mill is described. The amounts of air in different portions of pugged clay were compared by determining apparent specific gravities.

Pugging causes a segregation of the mineral constituents of a plastic body, and also causes uneven distribution of occluded air.

DENTAL CEMENT.—V. V. J. Andresen (*Pat. J.*, No. 1616, 1920). Pat. No. 134,757, April 9, 1919. A dental cement consists of zinc oxide, alum, and a suitable liquid such as water. Eugenol, oil of cloves, zinc sulphate or chloride, copper sulphate, phosphoric acid, or a condensation product of eugenol and formaldehyde may be added to increase the depth of the anaesthetizing effect. Suitable proportions are 45 parts of zinc oxide, 15 parts burnt alum, 15 parts concentrated solution of zinc sulphate (or other substance mentioned).

ELECTRIC ENDOSMOSE.—Elektro-Osmose Akt.-Ges. (Graf-Schwerin Ges.) (*Pat. J.*, No. 1618, 1920). Pats. Nos. 135,221 and 135,222, June 25, 1918. Apparatus for removing liquids is constructed so that any spaces

with which the material treated is in communication, outside the drying chamber proper, are lined with or constructed in insulating material; choking of these spaces by solid deposits is thus prevented. In the dehydration of animal, vegetable, or mineral substances, the material is first forced into a cell of constant volume while water is removed and is then further treated, with simultaneous diminution of volume of the cell, after cutting off the supply of material. This diminution may be produced by movement of the electrodes, which may be actuated electrically, pneumatically, hydraulically, or mechanically; their motion may be automatically controlled in accordance with the pressure of charging or with the variation of current as dehydration proceeds.

ELECTRIC ENDOSMOSE.—Elektro-Osmose Akt.-Ges. (Graf-Schwerin Ges.) (*Pat. J.*, No. 1619, 1920). Pats. Nos. 135,815 to 135,820, June 25, 1918. Relates to apparatus for extracting or removing liquids from animal, vegetable, or mineral substances.

FILTER PRESSES.—R. W. Webster (*Pat. J.*, No. 1620, 1920). Pat. No. 135,976, Dec. 17, 1918. Each unit of a filter press is provided with one or more additional deposit-retaining surfaces in order to lesson the duty to be performed by the main filtering media.

FILTER PRESSES OPERATING WITHOUT CLOTHS.—(*Ker. Rund*, **28**, 30, 1920). I. The apparatus consists of a container in which is erected a column of thin metallic rings. These are pressed together by a screw arrangement, so that the space between the discs, through which the liquid escapes, can be regulated by pressure. The ring column is placed in the centre. The slip is introduced in the middle of the rings and pressure is exerted. The water is forced through the circular space between the rings, whilst the solid matter clings to the interior surface of the rings. This is removed automatically, so that the apparatus can operate without interruption. It is claimed that the new apparatus is a great advance on the old type, in which it is constantly necessary to renew the cloths.

II. This is an apparatus consisting of filter plates of porous material, the inner one being of large, the outer of fine pores. These plates are built into ordinary filter presses, and are said to give satisfactory results.

IV.—SHAPING AND MOULDING. DRYING.

ELECTRIC INSULATORS.—Fabbrica Isolatori Livorno (*Pat. J.*, No. 1616, 1920). Pat. No. 134,680, Dec. 19, 1918. Relates to high-tension transmission cables carried by two supports (of magnetic material) on the insulator so as not to touch the latter.

MOULDING HOLLOW BRICKS.—E. Quillet (*Pat. J.*, No. 1616, 1920). Pat. No. 134,704, Jan. 17, 1919. An illustrated description of a machine.

MOULDING BRIQUETTES.—St. Louis Briquettes Machine Co. (*Pat. J.*, No. 1617, 1920). Pat. No. 135,061, Feb. 5, 1919. An illustrated description of a machine for compressing pulverized combustible material between revolving cylinders to form briquettes.

ELECTRIC INSULATORS.—Fabbrica Isolatori Livorno (*Pat. J.*, No. 1618, 1920). Pat. No. 135,346, Dec. 19, 1918. In an electric insulator of the kind having a number of insulating parts separated by conducting parts forming a series of condensers, the areas of the conducting surfaces and the thicknesses of the insulating layers are so designed as to give a uniform potential-drop along the outside surface of the insulator.

ELECTRIC INSULATORS.—Fabbrica Isolatori Livorno (*Pat. J.*, No. 1619, 1920). Pat. No. 135,667, Dec. 17, 1918. Electric insulators of the

kind provided with a metallic hood have a metal rim interposed between the edge of the hood and the body of the insulator to distribute the electric stresses at this point. The outside edge of the rim is preferably bent upwards, and the insulator built up of a number of concentric members bound together by reinforced cement or the like.

ELECTRIC INSULATORS.—Fabbrica Isolatori Livorno (*Pat. J.*, No. 1619, 1920). Pat. No. 135,669, Dec. 19, 1918. Porcelain insulators for high-tension cables are provided with a thin metal sheet carrying the cable-binding wire or collar, and shaped to cover a large area of the upper surface of the insulator so as to distribute the electrostatic stress. In a built-up insulator, metal sheets are also inserted between the different parts. The metal sheets may be replaced by a conductive metallic varnish, for example a varnish made from linseed oil and fine aluminium powder, or linseed oil and minium.

ELECTRIC INSULATORS.—P. Venturini (*Pat. J.*, No. 1620, 1920). Pat. No. 136,102, May 22, 1919. Insulators have two hemispherical parts joined by an embedded pin, each part having a metal cap and a central expansion, which may be annular or cylindrical, integral with a cup.

ELECTRIC INSULATORS.—Westinghouse Electric and Manufacturing Co. (*Pat. J.*, No. 1620, 1920). Pat. No. 136,112, June 10, 1919. Insulators of the condenser type have insulating parts with bodies conforming to the electric field, while the metallic layers, or the insulating parts, are extended to form petticoats conforming to equipotential surfaces in the same field.

ELECTRIC INSULATORS.—V. Tedeschi (*Pat. J.*, No. 1620, 1920). Pat. No. 136,142, Sept. 30, 1919. Insulators are composed of a base and a cover which screws into or on it. The base is secured to a taper wooden plug driven into the wall. The cable, which lies in a groove in the base, is gripped by the cover.

ELECTRIC INSULATORS.—Fabbrica Isolatori Livorno (*Pat. J.*, No. 1621, 1920). Pat. No. 136,627, Dec. 17, 1918. Composite high-tension insulators comprise hemispherical cups of uniform thickness which are either nested together or arranged with their external convex surfaces in juxtaposition, and the connecting cement reinforced by metal netting and wire coils. A metal hood surrounds the porcelain bodies in the first arrangement (when nested), and a metal socket in the other.

ENLARGING AND REDUCING.—E. Behr (*Sprech.*, **52**, 43—6, 1919). A description of various methods of reproducing articles (vases, etc.) according to samples or sketches supplied, but in different sizes. Graphical methods (illustrated) of reducing or enlarging to scale.

V.—FIRING KILNS, OVENS, MUFFLES, Etc.

WOOD GAS FIRING OF HARD PORCELAIN.—M. Larcheveque, Manufacturer of Porcelain at Vierzon. Ville (*Cer.* 387, 1920). The French physician, Philip Lebon, was the first to invent an apparatus for the preparation of a combustible gas by the distillation of wood. In 1801, he produced a gas motor, with an electrical sparking attachment, and provided with a pump to compress the mixture of wood gas and air before firing.

Wood gas can be purified effectively by passing the products of distillation over a column of wood charcoal heated to redness. This converts the water vapour, pyrolignic acid, methylene, tars, etc., into oxides of carbon, hydrogen, methane, etc. The gas obtained by this method is sometimes known as Riché gas, and has a mean calorific value of 3,000 calories to the cubic metre.

An improvement on the Riché method was effected about 1908, by M. Goulet. The reducing column, instead of being maintained at red heat by means of an auxilliary furnace as in the Riché method, was kept at the required temperature by its own combustion, which was obtained by introducing air to the top part of the column.

The following is the result of experiments carried out in December, 1908, with a 25 H.P. motor and with chips of wood and shavings as distilling materials:

Shavings ..	Hygrometric water	15·30%
	Volatile matter	72·69%
	Ash	0·29%
	Fixed carbon	11·72%
Gas obtained ..	CO_2 in volume	5·33%
	CO	22·33%
	O	trace
	H	12·06%
	C_2H_2 (acetylene)	3·12%
	N	57·16%
Riché Gas ..	CO_2	21·33%
	CO	22·00%
	H.	44·20%
	CH_4	12·47%

The motor ran perfectly, and after a week the valves and cylinder showed no sign of becoming choked. The consumption of shavings per H.P. per hour averaged 740 grams.

In 1916, Goulet conceived the idea of uniting the gas with air by means of suction and forcing valve and of re-heating the mixture before combustion. The result was so satisfactory, that Goulet was encouraged to construct a small trial furnace, in which it was possible to fire hard porcelain, make glass, or melt steel in a crucible, in a few hours.

For the ceramic industry, therefore, the experiments carried out in 1916 are particularly interesting, in view of the possibility of obtaining high temperatures under conditions which enable a reducing, neuter, or oxidising process to be produced at will.

A temperature of 1.400° is very easily attained in a small rectangular furnace; porcelain is vitrified in less than an hour. An experiment was carried out with about a dozen saucers and egg-cups (one saucer glazed in colours, and several egg-cups were uncovered, *i.e.*, not in saggars). With a slow fire at first, afterwards increased, firing was complete in 3½ hours. The pieces were perfectly white and translucid and the coloured glazes well developed. The uncovered egg-cups were perfect. The exceptionally rapid firing, however, caused shrinkage of the glaze before the sulphur and fluor compounds were completely decomposed, the result being a somewhat porous glaze. This defect was not shown by the uncovered egg-cups.

Further progress has been made by Goulet since 1916, resulting in the construction of large generators to feed large motors. In February, 1920, a 400-500 H.P. generator, feeding four 50 H.P. motors by suction, and a re-heating furnace, was constructed. The firing experiment of 1916 was repeated on February 24th, 1920, about 1 cubic meter of porcelain being fired in saggars from 8-15 to 1 o'clock. The firing was much too rapid, especially at the commencement. In less than an hour the temperature exceeded 1000°. At 10 o'clock the shrinkage of the glaze was very advanced, and towards 11 o'clock, the temperature had reached 1400°. From 11 o'clock to 1 o'clock, the temperature was maintained between 1390° and 1410° without the slightest difficulty. A reducing, neuter or oxidising fire can also be produced with the greatest ease by regulating the gas valve and the aircock. The results of this experiment were substantially the same as that of 1916. The too rapid initial firing produced the same defects in the glaze, and the material of the saggars was completely destroyed. On

the other hand, the porcelain was extremely white and transparent, the body perfectly vitrified.

The following conclusions are justified by experience:

1. That wood-gas is suitable for firing hard porcelain and other ceramic products.
2. That the required temperature can be very easily obtained.
3. That it is extremely simple to obtain a reducing, neuter or oxidising fire at any time.
4. That the pieces can be fired naked. This method is therefore suitable for firing in the partition oven (stoneware, etc.)
5. Wood gas contains no sulphur, or ashes. It has all the advantages, without any of the disadvantages of firing with wood.
6. The firing is carried out under a pressure of from 10 to 70 or 80 c/m. of water, so that air cannot possibly enter.
7. To utilize this method and firing fully, kilns with continuous firing must be employed.

The economics realised by a tunnel kiln heated with gas for firing porcelains are the following: total elimination of the charging gang; reduction by at least one half, of the personnel required for intermittent kilns; suppression of wedges, frit basins, etc; facilities to reduce the height and thickness of saggars; rapidity in executing orders; numerous faults in firing avoided, *e.g.*, blistering, yellowness, black, etc.

Biscuit firing is, of course, necessary.

The article includes sketches and tables illustrating the process.

RATIONAL CHARGING OF TUNNEL KILNS.—P. le Groote (*Cer.* **23,** 105, 1920). One of the principal inconveniences of the continuous ovens usually employed, Hoffmann or Zig-Zag, is the strongly oxidising atmosphere due to the excess of air. To avoid the introduction of air when charging the furnace, a simple apparatus has been constructed by the Germans. It consists of a cylinder about 0·40 m. high partitioned in the centre by a plate, hinged at one side, in the form of a valve. This plate is held in its normal horizontal position by means of a lever, counter-weighted at one end, to which it is attached by a metallic wire. The neck of the cylinder is covered with a bell-shaped lid with an aperture at the top which is closed with a sheet of mica. It is thus possible to see into the shaft of the furnace when the plate is lowered. To charge the furnace, the lid is removed and the fuel deposited on the horizontal plate. The lid is then replaced, and by manipulating the lever the plate is made to swing open and the fuel falls into the shaft. The counter-weights on the lever may be arranged so as to balance a given charge of fuel.

ON ECONOMISING FUELS BY CONTROLLING COMBUSTION.—E. Martin (*Cer.* **23,** 97—103, 1920). The presence of carbon monoxide in the gases of combustion given off when any fuel is burnt, proves that combustion is not complete. Theoretically, a fire is running well, if the amount of CO_2 present in the furnace is as near as possible to that theoretically required for the complete combustion of the fuel in use, that is, there must be no CO present. To complete the combustion, air must be admitted to the furnace to convert the CO into CO_2. In practice, considerably more air has to be admitted into the furnace than that required in theory. On the other hand, too much air reduces the temperature unnecessarily.

To regulate the fire so as to produce the best results, it is necessary, therefore, to analyse samples of the gases for the percentage of CO_2 contained therein. But this obviously does not constitute a practical means of controlling the method of firing. This can best be obtained by measuring the difference of pressure above and below the fire. By experimentation in conjunction with the chemical analysis, the difference of pressure required to give the maximum result can be determined. By a suitable arrangement, the pressures can be transmitted graphically to a chart, upon which all stoking operations will then be registered.

TO WHAT TEMPERATURE MUST FIRE BRICKS BURN?.—R. M. Howe (*Brick and Clay Rec.*, **54**, 975-6, 1919). It is generally held that fire bricks should be burned in the kiln to the temperature at which they are subsequently to be used, in order to prevent contraction in service. The author submits data to show that this is not always necessary.

First grade Pennsylvania fire bricks which would be used for arches and sidewalls in furnaces operating at 1500°C., were heated at a suitable rate to different temperatures, and the following table of contraction and expansion was obtained:

Total Linear Changes for Different Temperatures:

1100°C.	·00	
1150°C.	·00	
1200°C.	·00	
1250°C.	.25	per cent contraction
1300°C.	·28	,, ,,
1350°C.	·30	,, ,,
1400°C.	·12	,, ,,
1450°C.	·18	,, expansion

The bricks had apparently been burned to about 1200°C. which was nearly sufficient to burn out most of the shrinkage. A temp. of 1250°C. was sufficient to complete the burn, since higher temperatures only resulted in causing a permanent expansion.

Similar bricks were heated under a pressure of 25 pounds to the sq. in. for one and a half hours, at 1350°C. and showed an average compression of 5.6%. Had the bricks, therefore, been heated to 1500°C. in the kiln, the weight would have been sufficient to cause those in the lower portions to have become distorted and bent. The softening temperature depends entirely upon the pressure to which the bricks are subjected. It has been shown experimentally that bricks can be vitrified by pressure alone. When in use, one portion of a fire brick is generally cooler than the other, due to radiation, and this cooler portion is able to bear the load and maintain the structure of the installation while the hotter and softer portion withstands the heat.

The writer believes, therefore, that it is not always necessary to burn fire bricks to the temperature at which they are to be used, and furthermore, that it is often impossible to do so.

COLLOIDAL FUELS.—(*Gas J.*, **147**, 614, 1919). A report by L. W. Bates for the Executive Committee of the Submarine Defence Association of New York. Coal and oil should be made to support each other. Colloidal fuels are composed of microscopic and ultra-microscopic particles of coal held in oil. Up to over 40% by weight of coal and 59% of oil, they are liquid, becoming denser, but not sticky as the coal percentage increases. They are pumpable up to 65% of coal. For steam raising, melting and moulding metals colloidal fuel possesses unique properties. It saves coal, and increases the thermal value of the tonnage from 25 to 75%. These fuels are vapourless, and thus create no explosive mixtures with air; they are immune from spontaneous combustion. A typical bituminous colloidal fuel contains 160,000 B.T.U. per gallon, or 1,196,880 B.T.U. per cubic foot, and may be made with anthracite and cokes up to 1,346,490 B.T.U. per cubic foot.

A LABORATORY HIGH-TEMPERATURE COKE-RESISTANCE ELECTRIC FURNACE.—W. F. Munn (*Chem. and Met. Eng.*, **23**, 345, 1920). This furnace can be employed for temperatures up to 2,300°C. One inch graphite electrodes and 1¼-in. graphite crucibles are used. The rods, which are supported by suitable pipe-fittings, pass through Silocel brick and continue to within about 1½-in. of the crucible. The space around the electrodes and crucible is filled with granulated coke. The entire furnace is constructed of 9 × 4½ × 2½-in. Silocel blocks. Temperatures of 2,200 to 2,300°C. have been obtained from a cold start in 20 min.

FUSIBILITY OF COAL ASH.—(*Eng. and Ind. Man.*, **13**, 410, 1919). The practical utility of a knowledge of the fusibility of coal ash lies in the fact that it enables coal users to specify the softening or fusing temperature of the coal ash, and thereby avoid excessive clinker troubles in their furnaces. The U.S. Bureau of Mines has published the results of a series of tests, and it is urged that a standard method of testing should be adopted.

Coal ash consists chiefly of silica, alumina, iron and lime, with smaller quantities of magnesia, titanium, alkali, sulphur and phosphorus compounds, but the chemical composition varies widely. The ash impurities come into coal in two ways: by being present in the original formations, and by being commingled with it through earth action or while it is being mined, transported, or stored.

Being a mixture of both crystalline and amosphous substances, coal ash can have no definite melting point, and it is not generally fused as the melting point of each constituent is reached, because reactions involving the formation of new and more fusible compounds take place, the melting points of which have their effect on the whole body. The softening and fusion of the ash is thus the result of chemical reaction, melting and solution, and is largely and directly affected by the time factor and the fineness of the constituents. The nature of the atmosphere in which the ash is heated, and the effect that the surrounding gases, whether oxidising or reducing, have on the iron oxides in the ash, also have a very great influence on its fusibility. Six furnaces were used for the comparative tests, each with its particular atmosphere, oxidising, reducing, or neutral.

The general conclusions arrived at show that ash ground to an impalpable powder tends to soften at a slightly lower temperature than ash that will pass a 100 mesh screen. The difference only averaged 6°C., but in maximum cases was as much as 40°C. Ash pulverised to at least 200 mesh was found to be best for testing purposes. Careful experiments showed that the best size of coal ash cone to use was one with a base about ¼-in. wide and with the apex ¾-in. vertically above the base.

Rates of heating slower than 2°C. per minute or faster than 10°C. are not advised. The atmosphere in which the ash was heated was much the most important factor affecting the softening temperature point. The highest softening points were obtained in an atmosphere of air, or in a strongly reducing atmosphere of carbon monoxide, which prevented the iron oxide from acting as a fluxing agent by reducing it to metallic iron before the softening of the ash began. The lowest softening temperatures were obtained in those atmospheres of mixed gases in which reduction of ferric oxide proceeded mainly to ferrous oxides, the most active phase in the reduction of iron ore as regards slag formation at lower temperatures. The maximum variation in softening temperatures due to different atmospheres ranged from 134° to 396°C.

It is advised that the method of determining the softening temperature of coal ash in a gas furnace with a reducing atmosphere, which is simple in operation, should be adopted as the standard method.

STONEWARE FLOOR TILES.—E. Tuschhoff (*Ker. Rund.*, **28**, 69,—70 and 79—80, 1920). A short description of the reactions taking place in burning dry-pressed sintered floor tiles, or mosaics, with suggestions for dealing with the faults which frequently occur. The raw material should be such as to give a completely sintered body at cones 7 to 9. A suitable mixture would be:

Clay (plastic)	45 per cent.
Quartz	42 ,,
Felspar	12·5 ,,
Magnesite	0·5 ,,

The tiles are dry-pressed and well dried prior to burning in circular down-draught kilns, fired preferably with hard, long-flame coal. Coke is suitable for the preliminary firing when large quantities of hot air are required to drive out the remaining water. The kiln temperature is best

measured by means of a thermometer which can be read from the outside. The following scale of temperatures has been found suitable in practice:

After 12 hours	60°C.
,, 24 ,, ...	80°C.
,, 36 ,, ...	100°C.
,, 48 ,, ...	130°C.
,, 58 ,, ...	160°C.

By this time, the free water has been removed, the fire is closed down, and another phase of the firing begins. Correct firing is most important. To prevent the deposition of soot and tar on the ware, the saggars should be made to fit closely one above the other. Though the hygroscopic water has been driven off, the ware still contains chemically combined water. As this is removed with the rising temp., the clay becomes porous and brittle. As is well known, the colour of the ware depends on the proportion of metallic oxides present (iron, cobalt, manganese, etc.). The desired colour, however, is only obtained if the metal in the clay remains in the form of the oxide. But the amount of oxygen in the kiln having been reduced by closing the fires, the gases of combustion, particularly after each fresh addition of fuel, act as powerful reducing agents. This leads to the deposition of carbon in the pores of the clay, and to the reduction of the metallic oxides to their respective metals. When the fuel charge has burned away, more than sufficient oxygen for combustion is present, and this re-converts the metals to the oxide form. The effect of the gases of combustion upon the ware depends, therefore, mainly upon the amount of fuel added at any given time and the interval between each charge.

The composition of the gases is also influenced by the strength of the draught, which determines the volume of air passing through the grate during the given interval. A pressure of 8—10 mm. at the bottom of the grate was found to give the best results. A recording draught gauge should be used to measure the strength of the draught.

The dark circular patches which often occur in the centre, where the two tiles are in contact in the kiln, are caused by the fact that the oxygen of the air cannot penetrate to these parts and thus counteract the previous reducing action.

To avoid the deposition of carbon when the ware has become porous (cone 010), it is better not to charge all the fires at the same time, but only one half at a time. The combustion of the gases from the charged fires is then effected by the hot air from the others. Better still is the system of introducing warm air through flues passing between the fires. At cone 6a, when the ware becomes quite soft, it is necessary to allow the pores to close very gradually, to prevent any of the gases being locked up in the pores. Blistering is often caused by the presence of pyrites in the clay, iron and SO_2 being released in a reducing atmosphere. The SO_2 reacts on the alkalis present and causes blistering. Pyrites in the fuel may also lead to the presence of H_2SO_4 in the ware. From cone 6a until firing is complete—cone 9 approx.—the temperature must be allowed to rise slowly.

MAKING BASIC ELECTRIC FURNACE BOTTOMS.—A. W. Lorenz (*The Foundry*, p. 403, 1918.) Electric furnace practice is mostly neutral or reducing, and for the best results the bottom should be as non-oxidizing as possible, oxide in the bottom being quite as active as oxide in the slag. Even the best magnesite contains iron oxide, but the percentage can be kept down by a judicious choice of the bonding material which is necessary to set the magnesite. Instead of using basic open-hearth slag in the usual proportions of one part slag to four parts magnesite, it would be better to use blast furnace slag (which is quite low in iron oxide). Its bonding power lies in its high percentage of alumina and silica, which are stronger bonding materials than iron oxide, so that blast furnace slag may be used in the proportion of 1 to 10. Alkali salts, such as sodium silicate, should prove equally satisfactory if used in sufficiently small proportion (much less than of slag).

Caustic soda or its salts may be dissolved readily in water, and in this condition may be mixed with the magnesite more thoroughly than is possible with any dry bonding material.

In making bottoms, the refractory mixture, slightly moistened, should be rammed well in layers an inch or so in thickness. After ramming each layer, it should be thoroughly burned-in or set before putting down the next layer, as in open-hearth practice. To cover the bottom of an arc furnace with coke and raise it to a white heat in a comparatively short time though extremely simple, is wrong in principle. Any iron oxide in the bottom will be reduced by the coke to metallic iron, which will collect in small deposits, reducing the strength of the bottom instead of increasing it. Moreover, the method facilitates the formation of calcium carbide; this reaction does not need the full heat of the electric arc, but begins at about 1500°C., and proceeds rapidly at 1800°C. Calcium carbide has been found in samples of blast furnace slag, and has been also found in bottoms burned-in by the method indicated. In foundries a basic electric furnace bottom invariably cracks and powders in a short time if the furnace lies idle, whereas a bottom made of similar materials in a basic open-hearth furnace will remain unaffected for months. To obviate the effects of the excessive reducing conditions, it is suggested that electric furnace bottoms be burned-in with gas or powerful portable oil burners, notwithstanding the increased labour and expense.

COMBUSTIBLES DURING THE WAR.—E. Damour (*Chim. Ind.*, **1**, 91T=379, 1918). A review of progress during the war. The subjects discussed include incomplete combustion, bad regulation of combustion, losses by smoke, carbonisation, gasification in producers, pulverised coal, liquid combustibles, and new combustibles. Coming under the last-named heading are peat, lignites, wood, and inferior coals.

ELECTRODE FURNACES.—Fabbrica Italiana Automobile Torino, Soc. Anon., F. I. A. T., (*Pat. J.*, No. 1616, 1920). Pat. No. 134,810, March 10, 1919. Addition to No. 121,485.

COKE OVENS.—A. Roberts (*Pat. J.*, No. 1617, 1920). Pat. No. 135,091, March 7, 1919. Relates to a special construction of a heating-wall formed of blocks, so that much more heat is transmitted to one face of the wall than to the other.

GAS RETORTS—Soc. Anon. D'Ougrea Marihaye (*Pat, J.*, No. 1618. 1920). Pat. No. 135,214, Nov. 15, 1919. Relates to vertical retorts of rectangular cross-section.

COKE OVENS.—Soc. Anon. D'Ougrea Marihaye (*Pat. J.*, No. 1618, 1920). Pat. No. 135,217, Nov. 15, 1919. Relates to a discharging device for a continuously-operated vertical coke oven.

ELECTRIC FURNACES.—Morgan Crucible Co. and C. W. Speirs (*Pat. J.*, No. 1618, 1920). Pat. No. 135,237, Oct. 12, 1918. Water-cooled terminals grip the ends of the heating resistance of an electric furnace with variable pressure so as to obtain a fine adjustment of the temperature. The parts gripped may be extensions on a resistant crucible or the like, or carbon conductors connected to a resistance surrounding the container, and may be cylindrical or conical, or of square or rectangular cross-section.

CRUCIBLE FURNACES.—W. A. Shilton and R. A. Munden (*Pat. J.*, No. 1618, 1920). Pat. No. 135,241, Oct. 17, 1918. The body portion of the furnace, which is made separate from the base and can be lifted therefrom to expose the crucible, is formed with a contracted central outlet beneath which the lining is of bottle neck shape to deflect the gases on to the metal in the crucible.

FLUES FOR RETORTS, OVENS, ETC.—W. E. Davies (*Pat. J.*, No. 1619, 1920). Pat. No. 135,549, Oct. 24, 1918. Consists of a construction and arrangement of heating-flues adapted to utilize gaseous, vaporous, or dust fuel or waste gases, and applicable to coke ovens, gas retorts, furnaces for treating oils, solid fuel, or metals, and the like. Three alternative

constructions embodied in a vertical or horizontal retort or oven of circular section are shown.

GAS MANUFACTURE.—A. J. Pennington and M. C. Lamb (*Pat. J.*, No. 1619, 1920). Pat. No. 135,577, Nov. 25, 1918. Relates to the utilization of the products of distillation of bones or leather containing volatile oils of the pyridene and analogous series.

LIQUID-FUEL BURNERS.—South Metropolitan Gas Co. and A. Kirby (*Pat. J.*, No. 1619, 1920). Pat. No. 135,583, Nov. 26, 1918. An illustrated description.

ELECTRIC FURNACES.—W. E. Moore (*Pat. J.*, No. 1619. 1920). Pat. No. 135,639, Dec. 7, 1918. A combined arc and induction metallurgical furnace has one or more inclined U-shaped channels in which currents are induced by coils wound on laminated cores.

ELECTRODE FURNACES.—J. Bibby (*Pat. J.*, No. 1620, 1920). Pat. No. 135,905, Nov. 28, 1918. Waste gases re-introduced into a shaft furnace for cooling the electrodes are rendered inert or of a reducing character immediately upon entry into the furnace.

GAS MANUFACTURE.—F. A. Umstead (*Pat. J.*, No. 1620, 1920). Pat. No. 135,931, Dec. 3, 1918. Relates chiefly to condensing plant and purifiers.

ELECTRODE FURNACES.—W. E. Moore (*Pat. J.*, No. 1620, 1920). Pat. No. 136,034, Feb. 13, 1919. In a polyphase arc furnace suitable for the manufacture of steel and its alloys, a hearth is connectible to different points along one of the transformer secondaries feeding the upper electrodes, so that the electric pressures of the arcs can be unbalanced and current directed through the bath.

TUNNEL KILNS.—J. H. Marlow (*Pat. J.*, No. 1620, 1920). Pat. No. 136,127, Aug. 11, 1919. Relates to tunnel kilns for firing or enamelling tiles, pottery, etc., and more particularly to those of the kind having interior longitudinal flame or heat conveying conduits. Cold air from pits outside the kiln is drawn into longitudinal conduits in the cooling-section of the tunnel, and after being treated therein is delivered, partly to the flame conduits in the firing section and partly by outlets for use in any desired part of the works. Dampers control the respective deliveries, and the conduits are preferably made of thin sheet metal.

RETORT FURNACES.—F. Cummins (*Pat. J.*, No. 1621, 1920). Pat. No. 136,398, Feb. 28, 1919. In a vertical retort setting having superposed chambers, holes are formed at the rear ends of the floors, through which the waste gases rise. Flues and dampers in the rear wall are thus dispensed with. Dampers control the passage of the gases into the circulating chambers.

ELECTRODE FURNACES.—H. A. Winne (*Pat. J.*, 1621, 1920). Pat. No. 136,500, July 18, 1919. A regulator for a multiple-arc furnace adjusts one electrode to produce constant current and also maintains equality or other constant ratio between the voltages of the arc from this electrode and of another arc.

COKING-APPARATUS; CONVEYORS.—C. D. Burney (*Pat. J.*, No. 1621, 1919). Pat. No. 136,585, Aug. 31, 1918. In distilling carbonaceous material at low or moderate temperatures, the main supply of gases for heating the material under treatment is generated in an external combustion chamber and is passed under control (to obtain the desired temperature gradient) through hollow-conveying-elements in the retort chamber.

SHAFT FURNACES.—A. Steiger and W. W. Steiger (*Pat. J.*, No. 1621, 1919). Pat. No. 136,588, Oct. 14, 1918. In a gas-fired shaft kiln for burning lime, magnesite, ores, and other non-sintering materials, of the kind in which the cooling-zone is enlarged at one or more points to loosen the descending material, a continuously-operated discharging-device is

used consisting of an inclined reciprocating table arranged in such a position that it is relieved from the weight of the charge.

ELECTRODE AND RESISTANCE FURNACES.—L. C. Harvey (*Pat. J.*, No. 1621, 1919). Pat. No. 136,679, Jan. 9, 1919. A melting chamber continuously rotating about an inclined axis is open at one end, through which extends a non-rotary heating-device.

ELECTRIC HEATING APPARATUS OF CERAMIC MATERIAL.—Schneider (*Ker. Rund.*, **28**, 99—100, 1920). Though the war conditions gave considerable impetus to the manufacture of electric heating appliances out of ceramic materials, they are by no means to be considered merely as emergency substitutes. The advantages claimed over metal are: (1) The insulating property of the material renders considerable simplification possible in the construction. (2) the glazed surface of the apparatus can be kept perfectly clean, and under the influence of heat does not lose or change its colour or give off unpleasant smells. It is, in fact, perfect from the hygienic point of view. (3 the thermal properties of the material are also favourable. Both absorption and radiation take place gradually and uniformly, so that rapid changes of temperature, dry or dusty atmosphere, are avoided. The apparatus illustrated in the article include lamp-stoves, radiators, foot-warmers, warming-plates for heating irons, etc.

ON PLACING WALL TILES.—(*Sprech.*, **52**, 180, 191, 1919). The composition and thorough mixing of the saggar body is very important. The saggars must be properly dried and burned in a sharp fire. Care must be taken to see that the ware is thoroughly dry before placing in the saggars. Monochrome tiles may be placed pairwise in horizontal or vertical positions, but tiles in various colours must not be allowed to touch. Relief tiles are best placed singly, separated from each other, and the saggar filled with sand. The best method of placing depends entirely on the behaviour of each body. After biscuit firing, the tiles are usually placed upright in the saggars, leaning slightly in one direction, the glazed surfaces facing the other way. The tiles are held in position by thimbles. They are sometimes, however, arranged in pairs with the glazed sides facing each other. They may be fired in a horizontal position by means of cogged supports of porcelain or stoneware.

HEATING FURNACES AND ANNEALING FURNACES.—W. Trinks (*Blast Furnace and Steel Plant*, **8**, 509—11, 1920). An article discussing methods for strengthening side, partition and bridge walls, door arches and door jambs. In very large walls, the difference in temp. between the inside and outside causes considerable variation in linear expansion. This leads either to a cracking of the outside layers or to a tendancy of the wall to buckle into the interior of the furnace. If the wall is well bonded to the centre or outside, no trouble will arise. The thickness of the bonded wall should grow with the extent of the unsupported wall. But firebrick and red brick do not bond well together because of the difference in size; firebricks and silica bricks measure $9 \times 4\frac{1}{2} \times 2\frac{1}{2}$ inches, while common red bricks are $8\frac{1}{4} \times 4 \times 2\frac{1}{2}$ in. Pressed bricks again measure $8\frac{3}{8} \times 4 \times 2\frac{3}{8}$ inches. The shortest side, whether it be height or length, should be used to determine the thickness of the unbonded firebrick wall. In high temp. furnaces, we may use $4\frac{1}{2}$ inches of firebrick up to 4 feet in length, 9 inches up to 8 feet of length, and $13\frac{1}{2}$ in. up to 12 feet in length. In 1600° to 1800°F. furnaces, these lengths may be exceeded 40 to 50%. Greater unsupported lengths require 18 in. of firebrick or auxiliary supports, such as steel hooks. If silocel brick is used for insulation, it must be protected on the outside by metal plates or red bricks, bec ause it is soft and brittle: further, it is used in thin layers ($2\frac{1}{2}$ or $4\frac{1}{2}$ in.) which require additional support.

The peeling off of the inner layer has hitherto prevented the use of the only correct design of the side walls and arches for batch annealing furnaces. The loss of heat might be halved by the use of a perfect insulator. Calcined

silocel brick should be tried for this purpose, but the problem of holding a 1¼-in. layer of firebrick safely on to a vertical wall has not yet been solved.

With arches of wide span it is frequently considered safest not to rest them on the side walls, but on skewbacks which are held by the backstays. This construction is best for the arch, but the walls are no longer protected from falling inward. The top bricks have a tendency to crawl inwards.

Flue openings in the side walls of forge and reheating furnaces, with temperatures of 2,100 to 2,300°F., are apt to be troublesome. The tile which spans the flue, and the bricks above it receive convection heat from all sides, and hard firing softens the tile and results in gradual closing of the flue. A suitable refractory material for this purpose is "Suprafrax." Silica bricks have been tried, but rejected, because their expansion is so different from that of fireclay, sharp cracking being the result. Furthermore, silica bricks undergo crystallization near 1200°F. and must be heated or cooled with extreme slowness through this critical range.

In the high temp. drop forge furnace the walls and arches wear out rapidly. Furnace temperatures near 3000°F. mean "sweating" or fusing of the refractories. A possible solution lies in making the walls so thin that the outer, colder layers by their own mechanical strength, hold up the inner soft layers. This involves tremendous heat losses, unless most of the heat can be returned. The writer has attempted the latter feat by designing a furnace with thin side walls, thin hearth and thin roof. Air circulates all round and is preheated on its way to the burner. On the inside of the furnace, heat passes through the 4½ in. wall into a cast iron ribbed shell. The ribs serve three purposes: they guide the air on its course, transmit heat to it, and hold the outer layer of calcined silocel brick in place. On account of the length of the air path, there is a drop in pressure of several inches of water through the length of this path, and the air is kept from leaking out by an air-tight steel shell surrounding the silocel. The design is heavy and expensive compared with present practice. There appears at present to be no inexpensive way of constructing these furnaces to last, unless a recently published German method proves successful. According to that method, the inside of the furnace is painted with a mixture of 75% carborundum sand and 25% silicate of soda.

Arches over doors, particularly double doors frequently collapse, especially in forge furnaces. Flames wash all round the pier, causing its temp. to rise considerably above that of the straight sides. The corners soften and yield, the resulting inclination tips the door arch and allows it to fall into the furnace. The pier must therefore be made of special refractory firebrick, no matter what the cost. In very large furnaces pipes can be arranged for the circulation of cooling water. Similar conditions apply also to partition walls and bridge walls. One of the best expedients for maintaining bridge walls in high temperature furnaces is to introduce secondary air through the centre of the wall. Bridge walls should be thicker than the side walls. If the vertical dimension between supports exceeds the horizontal one, the thickness may be 1/6 of the span for 1600°F., and ¼ of the span for 2,200°F. furnaces. But if the horizontal dimension exceeds the vertical dimension, the wall must be ½, or even 60% of the unsupported height for 2,200°F. furnaces, and ⅓ of that height for 1,600°F. furnaces.

ABNORMAL DRAUGHT CONDITIONS IN PORCELAIN OVENS THE CAUSE OF VARIOUS FAULTS IN BURNING.—O. Wilhelm (*Sprech.*, **52,** 115—7, 1919). During the whole of the reduction period the flame should be a brilliant red but non-transparent. If, after stoking, the flame becomes darker in colour, and smoky, more air must be allowed to enter; when, however, the individual sets of saggars are discernable, it is time to re-charge with fuel. It is advantageous to stoke frequently with small quantities of coal, this does not reduce the temperature in the fire box unduly, and gives rise to comparatively small volumes of smoke. Throughout the firing, the gratings must not be allowed to become choked, clinker

should be carefully removed every 3 to 6 hours. An alteration in the draught conditions will cause all kinds of complications in an otherwise satisfactorily working kiln. A too powerful draught will lead to the ware in the centre of the kiln being incompletely fired, whilst in other parts it is over-fired, yellow and blistered, and the biscuit oven receives insufficient heat. A variation (after repairs, for instance) in the number or thickness of the bars in the grating may have serious results. If the space between the bars is decreased, the air passes through at a higher velocity, and a strongly oxidising flame is the result; if the space is increased, or the number of bars decreased, the opposite effect is obtained, *i.e.*, the flame has strongly reducing properties.

REACTIONS WHICH TAKE PLACE DURING THE BURNING OF CERAMIC WARE.—W. Pukall (*Sprech.*, 61—2, 69—70, 77—8, 1919). The changes occuring during the progress of the firing are most important. Decarbonization can only begin after complete dehydration of the body. So long as water-vapour, CO_2, etc., are being given off from the clay, the oxygen of the air cannot enter the pores, so that oxidation cannot take place. Dehydration is naturally accompanied by a reduction of the temperature of the ware itself as compared with that of the surrounding gases, with consequent deposition of soot, distillation products, etc. With a slow fire, this process is completed at about cone 07a. Dehydration requires heat only, decarbonization demands both heat and a plentiful supply of oxygen. When all volatile and combustible matter has been removed, the body may be said to be properly "burned." It is now practically at the same temp. as the surrounding flame, so that no further deposition of soot, etc., takes place. The carbon deposited in the pores is alone responsible for faulty firing. It is unavoidable, but can easily be removed by careful firing. The writer's opinion is that the so-called reduction period is of quite subsidiary importance. It should not be introduced until decarbonization is quite complete, and then a mild reducing flame with little or no smoke is quite sufficient to reduce the iron ixode. The development of large volumes of smoke is only necessary in the dehydrating period. The article concludes with a few hints as to the proper treatment of certain glazed and unglazed wares.

UTILITY OF ROTARY GRATE GENERATORS.—E. Störch (*Sprech.*, **52**, 38—9, 1919). A reply to C. Jung (TRANS. **18**, abs. 147). In support of Rotary Grate Generators.

UTILIZATION OF WASTE HEAT AND SMOKE GASES.—H. Herda (*Ker. Rund*, **28**, 100-1, 1920.) On an average, only 1·7 % of the fuel consumed in making pottery goes towards actually firing the ware; the rest, for the most part, is lost. The waste heat given off by a kiln after firing is complete, may be utilized in the following four ways:—

1. For "smoking" purposes.
2. As secondary air to assist combustion.
3. As a source of power by heating boilers.
4. For heating rooms in the factory, dryers, etc.

The first of these is the most effective. The hot dry air is conducted by the shortest way from one oven to another, and is eminently suited to absorb large quantities of moisture. At the same time, no impurities, such as soot, are brought into contact with the ware.

The smoke gases may be passed through regenerators, in which the heat is transferred to currents of air. The waste energy is best recovered, however, by mixing the smoke gases with the waste heat from the kilns by means of forced draughts. A thorough mixing of these two would ensure complete combustion.

INDICATORS FOR CARBON DIOXIDE AND OXYGEN IN AIR AND FLUE GAS.—L. H. Milligan, D. O. Crites, W. S. Wilson (*U.S. Bureau of Mines, Tech. Paper*, 238, 1920). Three instruments are described—

one for CO_2 in air, one for CO_2 in flue gas, and one for oxygen in air.

(1) The indicator for CO_2 in air is calibrated to read from zero to 5% CO_2 and the results are accurate to within about $\pm 0{\cdot}2\%$. The instrument, which is fully described and illustrated, is a glass apparatus filled with caustic soda solution, which is made by dissolving 10 grams electrolytic stick sodium hydroxide in 100 c.c. water. A more concentrated solution would tend to adhere to the walls of the sample chamber and capillary tube. To prevent absorption of CO_2 during sampling, the surface of the caustic solution in the sample chamber is covered with a thick layer of Russian white oil. To effect absorbtions of CO_2 in the sample, the instrument is shaken vigorously for about half a minute. A humidifier, consisting of a brass tube containing moist cheeze cloth, which is attached to the inlet valve of the indicator, is used to prevent the humidity of the air sample, which may vary between wide limits, from affecting the percentage of CO_2 (2) The indicator for CO_2 in flue gas resembles the previous instrument, but in addition to the humidifier it has a filtering and cooling device, so that a clean flue gas is delivered into the sample chamber at the temperature of the indicator. It is calibrated to read from zero to 17% CO_2 and the results are accurate within $\pm 0{\cdot}5\%$. (3) The indicator for oxygen in the air is calibrated from zero to 23% oxygen and the results are accurate to within about $\pm 0{\cdot}5\%$. It is similar in construction to the two previous instruments. The oxygen is absorbed in a solution made by dissolving 120 grams potassium hydroxide in 80 c.c. water and mixing with 5 grams pyrogallic acid dissolved in 15 c.c. water. This solution is a relatively slow absorbant of oxygen, so that 10 c.c. Russian oil is found sufficient to cover the surface in the sample chamber. As the alkaline pyrogallate solution also absorbs CO_2 readily, this gas is removed from the incoming air sample by means of a long brass tube, filled partly with granular soda-lime and partly with calcium chloride, fastened to the needle valve in place of the humidifier.

These indicators were used, with satisfactory results, to test the air in a submerged submarine, on August 1st, 1918.

GENERATOR FUEL.—(*Sprech.*, **52**, 463, 1919). To avoid loss of heat energy the fuel should be as dry as possible. The gas producers should be modified in form and size to suit the particular circumstances. The height of the charge in the generator varies according to the fuel used. The writer describes a method of regulating this quantity.

THE DURABILITY OF THE BURNERS IN GLASS FURNACES.—H. Knoblauch (*Sprech.*, **52**, 407—11, 1919). Premature wearing of the furnaces is often unjustly attributed to the quality of the building material, or the method of firing. The importance of irregular variation of the gases in this connection is also often over estimated. The author shows, with the help of several sketches, that the form and construction of the burners are often responsible for much trouble. To prevent premature development of the flame inside the burners, the latter are partly divided off so that the gas and air are allowed to mix just prior to entering the melting chamber.

GAS FIRING OF PORCELAIN.—A. Nowak (*Sprech.*, **52**, 384, 1919). The problem is dealt with from the point of view of the coal shortage in Germany. Gas firing offers the possibility of utilizing brown coal. Ordinary coal-fired furnaces are not suitable for gas-firing; the draught is too strong, the flame too short. The amount of air entering the furnace must be carefully regulated. This is best effected by means of "pendulum valves."

FIRING STONE WARE.—M. Schmidt (*Sprech.*, **52**, 335—6, 45—8, 59—62, 71—3, 1919). A general survey of modern methods from a practical point of view.

GAS FIRING IN THE PORCELAIN INDUSTRY.—T. Hertwig (*Sprech.*, **52**, 311, 1919). For successful firing, the following points should be observed: (1) Gas fired bodies should contain at least $16{\cdot}9$ SiO_2 for $0{\cdot}86$ K_2O

in the Seger formula; (2) the glaze should contain no free felspar, it must be added in a fused condition; (3) the glaze must not contain burned kaolin, a plastic clay should be added; (4) for cone 14, glazes must contain at least 11 SiO_2 instead of the usual 8 SiO_2; (5) the glaze should contain not less than 0·2 MgO.

VI.—GLAZES AND GLAZING. ENAMELS.

RELATIONS BETWEEN FUSIBILITY AND HEAT RANGE IN GLAZES.—(*Sprech.*, **52**, 87—8, 1919). Taken from H. F. Staley's paper in *Trans. Amer. Cer. Soc.*, **15**, 694, 1913. (See Abs. TRANS. **14**, 18, 1914).

FLUORIDES AS OPACIFIERS.—(*Sprech.*, **52**, 53, 1919). A review of J. B. Shaw's paper published in *Trans. Amer. Cer. Soc.*, **16**, 577—79, 1914.

USE OF SUBSTITUTES FOR TIN OXIDE IN GLAZES.—R. H. Minton (*J. Amer. Cer. Soc.*, **3**, 6, 1920). Report of an investigation with various materials, including "terrar," zirconia from several sources, fluor spar, white antimony oxide, hydrated alumina, cryolite, "leukonin," "stannolite," "phosphorite" and "lithopone". "Terrar" is probably composed largely of zirconia and zirconium silicate. "Leukonin" is essentially sodium metantimonate. "Stannolite" and "Phosphorite" are compounds of unknown composition (from Wengers, Ltd., of Etruria). "Lithopone" consists of 30 per cent. zine sulphide and 70 per cent. barium sulphide. In the case of a *raw lead glaze* (of given composition) fired at cone 02, none of the substitutes showed much promise, though terrar might show results if used in much larger amounts (at least 0·15 equivalent of tin oxide would be required for a good opaque glaze.) A *fritted wall tile glaze* at cone 02 gave similar results, pure zirconia showing no opacity whatever. With a *terra cotta raw glaze* at cone 6, pure zirconia seemed equal to tin oxide for opacity, though the glaze was not so white. Antimony oxide was equal to tin oxide for opacity, but the glaze was not fully developed. Alumina produced a very good opaque matt glaze. Leukonin seemed almost equal to tin oxide for opacity, colour, and gloss. In a raw porcelain glaze at cone 9, terrar and zirconia (especially the pure) seemed to offer possibilities of being good substitutes. More material (than of tin oxide) might be required for the same opacity, but the other defects could no doubt be overcome.

The general conclusions are that: (1) zinc oxide is of great assistance in producing opacity with tin oxide and with the substitutes, as shown in the terra cotta and porcelain glazes; (2) barium oxide exerts a marked influence on opacity, as shown in the terra cotta glaze compared with the porcelain glaze; (3) zinc oxide and barium oxide have more influence on opacity than the clay content; (4) a glaze of the terra cotta raw glaze type, with both barium and zinc oxides, is most favourable for opacity, with either tin oxide or substitutes; (5) where they can be used leukonin and antimony oxide are cheaper than tin oxide, but zirconia is the best substitute for tin oxide if it can be procured at a sufficiently low price.

DEVELOPMENT OF TERRA COTTA GLAZES.—E. C. Hill (*J. Amer. Cer. Soc.*, **3**, 13, 1920). An investigation of the effect of adding tin oxide, barium carbonate, magnesium carbonate, strontium carbonate, or several of them to Bristol glaze mixtures. The mixture developed by Watts, having the molecular formula 0·4KNaO, 0·3 CaO, 0·3 ZnO, 0·6 Al_2O_3, 3·55 SiO_2, is no doubt the best that can be produced from these Bristol glaze mixtures as a bright, opaque, white glaze for stoneware, but it is not the most fusible mixture of the components. The author found that this glaze could be made considerably more fusible by the reduction of clay; the low clay glaze would not be satisfactory for stoneware, as it is transparent, but as a basis for introducing other materials used in the production of terra

cotta glazes it gave much better results than the entectic glaze developed by Watts. It is quite likely that in the low clay glazes a further increase of silica would produce more fusible glazes. The most fusible mixture actually made was 0·40 K_2O, 0·30 CaO, 0·30 ZnO, 0·45 Al_2O_3, 3·25 SiO_2, 0·05 clay, 0·75 flint; the corresponding mixture with 3·45 SiO_2, 0·15 clay, 0·75 flint was somewhat less fusible, though as a cone it showed even earlier deformation. As the felspar increased, additions of clay made the mixtures less fusible, until with 0·50 equivalent felspar there was a great difference in the fusibility of mixtures containing 0·05 and 0·15 equivalent clay respectively. It is evident that clay increases the fusibility of the mixtures only when there is a considerable amount of lime present and in mixtures like those here in question the CaO must be at least 0·40 equivalent. Lime is the only component of a Bristol glaze that reacts readily with clay to form fusible mixtures. Mixtures such as the most fusible one referred to above (including 0·05 clay, etc.), with equal amounts of CaO and ZnO and low clay, will probably be found more fusible than any high lime high clay mixtures possible with these components. But a certain amount of lime is essential to this type of glaze, as it cannot be replaced readily by any other components without decreasing the fusibility.

In terra cotta glaze mixtures magnesia decreased the fusibility of both high clay and low clay glazes, and the MgO series was more fusible than either the BaO or SrO series. BaO produced the least fusible of all the glazes tried. Seger's dictum that lime and magnesia instead of lime or magnesia increased fusibility was not confirmed in these glazes. Neither SnO_2, MgO, BaO, or SrO reacts readily with clay to form fusible mixtures, and as neither felspar nor zinc oxide reacts readily with clay, it may be stated that in mixtures containing all these, (in whatever amounts or combinations) the addition of clay will result in a less fusible glaze unless there is a considerable amount of lime present. In this respect the behaviour of lime is entirely different from any RO elements ordinarily used in this type of glaze.

SOLUBILITY OF BORIC ACID FRITS.—G. Blumenthal, Jr. (*J. Amer. Cer. Soc.*, **3**, 152, 1920). Tests of nine frits (of unknown composition) showed that all were more or less soluble in water. The most soluble was a poorly fused frit, and with one exception those which were well fused were least soluble, even when the fritting was carried out in saggars. Generally the more soluble the frit the more silicic acid separated out on prolonged shaking, though an exception was found in the same frit, which was exceptional as regards solubility. Thorough grinding and mixing of the constituents are to be recommended in saggar fritting; otherwise, the comparatively low temperature reached and the consequent high viscosity may limit the dissolving action and leave much flint unacted upon or insufficiently combined.

ELECTRIC CLEANING OF METALS FOR ENAMELLING PURPOSES.—W. C. Lindemann (*J. Amer. Cer. Soc.*, **3**, 252, 1920). Relates to the application of the cleaning methods used in electroplating to the enamelling process. The advantages over the older scaling or burning-off method are given as: (1) lower cleaning costs; (2) saving in time with corresponding greater output; (3) elimination of oxide sludge; (4) elimination of the sponging or scrubbing of ware, to remove the deposit of carbon formed during scaling.

TITANIUM ENAMELS.—R. D. Landrum and L. J. Frost (*J. Amer. Cer. Soc.*, **3**, 316, 1920). Trials were made with ten compositions containing rutile, all of which were very difficult to work as enamels, and probably have no practical value as such. The chief difficulty was to keep them suspended properly, owing to the high specific gravity of the frits.

The authors conclude that too high a content of TiO_2 increases the specific gravity so much that it is extremely difficult to keep it in a satisfactory state of suspension by ordinary means, that the yellow coloration does not depend only on the amount of rutile, and that the opacity also is some-

what independent of the amount of rutile present, and possibly more dependent on the composition of the enamel. Practically all enamels containing rutile show unusual durability, under all tests—chemical resistance, resistance to abrasion, heat resistance, and resistance to impact. Rutile is not suitable for a ground coat.

VII.—COLOURS & DECORATIVE PROCESSES

THE ARTIST'S PLACE IN THE CERAMIC INDUSTRY.—J. Beck (*Ker. Rund.*, **28**, 80, 1920). An article pointing out the advantages, both to the artist and the manufacturer, of giving wider scope to the creative faculty. The artist should be allowed to co-operate with the Sales Department and encouraged to study home and foreign requirements.

THE PHYSICAL BASIS OF COLOUR TECHNOLOGY.—(*Colour Trade Journal*, **2**, 39, 1918). Based on article by M. Luckiesh in *Met. Chem. Eng.* for Dec., 1917, in which it is stated that (1) the quantitative determinations of the spectral characteristics of coloured materials provide the foundations for many important aspects of colour technology: (2) with such data, and those derived from less analytical methods, many interesting facts and relations can be revealed and various factors can be studied which are unapproachable from the viewpoint of chemistry or from ordinary inspection; (3) the colour of an object can hardly be considered as being inherent in the object since it depends so much upon the spectral characteristic of the illuminant. That the illuminant should be considered as almost a part of a coloured medium.

In the analysis of colour, the method of the spectrophotometer is the most analytical, and it provides data far more useful in the physics of colour than are yielded by any other method. Reflection (or transmission) factors of the colouring media determined for radiant energy of all wavelengths in the visible spectrum, when plotted, give the spectral reflection (or transmission) curves for the visible spectrum. By the same method the spectral character of an illuminant may be obtained. By multiplying the relative energy-values of the various wave lengths of any illuminant by the corresponding visibilities of radiation, the spectral luminosity distribution curves are obtained for a given illuminant. These latter will vary with the illuminant and are often of greater importance than the spectral energy-distribution curves from a visual viewpoint. By multiplying corresponding spectral valves the spectral energy-distribution and luminosity distribution curves of any coloured medium may be readily obtained for any illuminant. For most purposes only relative values are necessary, but there should be no difficulty in distinguishing between relative and absolute values.

The monochromatic colorimeter, which yields data in terms of hue, saturation, and brightness or luminosity, is the most generally analytical among the so-called colorimetric methods. This method analyzes colour from the subjective viewpoint, and yields data which may be readily visualized by one possessing some experience and an acquaintance with the spectral hues. From a subjective viewpoint the monochromatic colorimeter appears the most feasible method upon which to base a scientific nomenclature of colour, which is urgently needed. An advantage of this method lies in relating the analyses to the constant and reproducible visible spectrum; however, in determining the saturation (unity minus the percentage of white) a white light is necessary, and this has not been standardized. A further difficulty lies in the unsettled state of colour-photometry, which is necessarily involved in determining the luminosity or refraction and transmission factors.

The trichromatic colorimeter yields analyses in terms of three arbitrarily chosen primary colours—red, green, and blue. This is based on the fact that any colour may be matched in hue by a proper mixture of these three properly chosen primaries. This method is not very analytical, and it is quite difficult to visualize a colour from an analysis by this method; the data are often misleading to those not familiar with their limitations, because the comparisons are made from the subjective standpoint.

The spectro-photometer is the most analytical method of colour-analysis, and its results are definite because standards required are readily available. The lack of standardization of a "white" light and the unsettled state of colour-photometry mitigate against the usefulness of the data obtained by the monochromatic and trichromatic colorimeters. Much standardization is needed in the terminology notation and analysis of colour.

The colour of a finely divided pigment, whether the particles are separated by air or by a vehicle, is due to innumerable selective reflections from, and transmissions through, the minute particles. There is always reflected from pigments (especially when a smooth surface is given by pressure) some radiant energy which is practically unchanged in spectral character which partly accounts for the general lack of purity of the colours of pigments. The refractive indices of the pigment and of the vehicle (air in the case of dry powders) are important, as they affect the amount of light regularly reflected from a surface. The porosity of a pigment surface affects the colour, as is readily seen by comparing the colours of white cotton and silk fabrics after soaking both in the same dye solution. The silk fibres are more transparent than cotton fibres, and permit the radiant energy to penetrate more deeply, so that the silk fabric appears of a purer colour; the result in the case of silk is similar to what would be obtained with cotton if dyed in a more concentrated solution of the dye.

The solvent appears to have certain influences upon the colour of a dye-solution, but this subject has been little studied. The spectral transmission factor of a dye-solution is a simple logarithmic function of the depth of a given solution or of its concentration, but this relation varies with the wave length—generally with no definite relation between wave length and spectral transmission factor. Hence no simple relation between total transmission and depth or concentration can be established.

Coloured glasses can be treated much in the same manner as dye-solutions. A given concentration of colouring material in a glass (that is, a given coloured glass) apparently obeys the same law relating to thickness and transmission factor for a given wave length as a dye solution. It is not established that the introduction of various amounts of the colouring material (generally metallic oxides) results in corresponding concentration, as would be true in the case of dyes. In glass there is more or less chemical action, and the uncertain conditions of melting make this point difficult to decide.

Spectral analyses in the ultra-violet and infra-red regions (which are of importance) are briefly alluded to.

The mixture of dyes is governed by the same subtractive principles of colour-mixture as the mixture of pigments. The vast variety of dyes and the sharpness of their absorption bands make it possible to obtain purer and brighter colours from this class of media than from others. Fairly pure blues and violets are rare, many so-called red dyes transmit deep violet light, all yellows transmit some green, yellow, orange, and red. Among the greens are many dichroics—transmitting deep red light; but there are excellent yellowish green dyes of fair purity.

By combining various dyes almost any degree of purity of colour can be obtained. Thus, eosine exhibits a sharp absorption in the yellow region of the sprectrum. By combining with this a yellowish green with a sharp cut-off in the orange region a fairly satisfactory yellow can be obtained. By mixing ethyl violet (which transmits deep red and deep violet) with an orange such as chrysoidin or a fairly concentrated solution of eosin a deep red is obtained. A deep violet may be obtained by mixing a blue-green

(which transmits no deep red) with ethyl violet. The subtractive principles of colour mixture are applied to the spectral curves in order to predetermine the results.

With spectrophotometric apparatus well maintained, a complete spectral analysis can be made in about an hour. For a given colouring material only one analysis need be made to provide information for all degrees of concentration or depth of solution.

In the combination of glasses for special filters, lighting effects, etc., the computational method often saves time and provides definite data. Sometimes only the subjective colour is desired, but even in these cases spectral analyses of elemental colourings provide the basis for manipulating the available vitrifiable coloured media in a manner analogous to the combination of pigments. By combining various colouring materials the variety of coloured glasses can be enormously extended to meet the requirements of science and art.

CHROME-PHOTO-CERAMICS.—C. Heck (*Sprech.*, **52,** 209, 1919). A short description of the method of reproducing all the colours of a water-colour or oil painting in photo-ceramics, using only three or four enamel colours.

PATCHES ON COBALT WARE.—(*Sprech.*, **52,** 273, 1919). Patches of cobalt, lighter in colour than the ground itself, sometimes appear on the unpainted portion of porcelain ware having a wide cobalt ground. To avoid this, the colour must be thoroughly calcined before using, and the body should be thoroughly dried. The patches may be caused by the oils in the colour, which boil up during the firing, forming blisters which burst. The cobalt oxide may also have the property, during the first period of firing, of absorbing oxygen, which is given off again in a reducing atmosphere. This will cause blistering and consequent smudging of the ware. Finely ground clay should be mixed with the colour in the proportion of 4:5, the mixture calcined, re-ground and washed. The addition of 20% alumina also has a good effect.

COMBINED STAMPING AND SPRAYING PROCESSES.—R. Seidel (*Sprech.*, **52,** 95—6, 1919). In the writer's opinion the limitations of the rubber-stamp process for decorating ceramic ware, can best be overcome by powdering with the pneumatic sprayer. This is said to give satisfactory results, without dispensing with the great economic advantages of the stamping process.

UNDER-GLAZE BLACK PRINTING.—H. Fieth (*Sprech.*, **52,** 37—8, 1919). The colour is made from finely ground Bohemian pitchblende, with or without small additions of ferrous oxide, cobalt oxide, and a little glaze. The powdered pitch blend is calcined in a porcelain oven, washed and dried. The above substances are then added, if necessary, and the mixture is re-ground. Fine grinding and thorough drying are important. The plates (steel or copper) must be etched fairly deep and then polished. A good varnish is important, to facilitate the transfer of the colour to the ware. After removing the paper from the transfer, the ware is allowed to dry, and then burned again, to remove all oily matter. It is then ready for glazing. Good lime glazes give the best results.

COBALT OXIDE.—N. B. Davis (*J. Amer. Cer. Soc.*, **3,** 322, 1920). A brief general survey of the production and use of cobalt oxide.

TUNGSTEN AND MOLYBDENUM COLOURS.—T. Hertwig (*Sprech.*, **52,** 199—200, 1919). The following mixture gives a good orange powder colour:

Tungstic acid	58·95	parts by weight
Aluminium oxide	7·75	,, ,, ,,
Uranyl chloride	6·06	,, ,, ,,
Manganese di-oxide	9·94	,, ,, ,,
Manganous chloride	16·31	,, ,, ,,
Iron sulphate	0·99	,, ,, ,,

It is fired at cone 014; the addition of 1·98 parts boric anhydride improves the tone. Red tungsten colours were obtained by dissolving sodium or potassium tungstate 1:1 in water. This solution was painted over a glaze of the following composition:—

$$\left.\begin{array}{l} 0{\cdot}94\ K_2O \\ 0{\cdot}05\ CaO \\ 0{\cdot}01\ FeO \end{array}\right\}\ 1{\cdot}79\ Al_2O_3 : 14{\cdot}35\ SiO_2.$$

fired wet, and then painted over with concentrated manganese salt solution and fired again. (Wet firing improves the colour). On a body of the type

$$\left.\begin{array}{l} 0{\cdot}4\ K_2O \\ 0{\cdot}6\ CaO \end{array}\right\}\ 2{\cdot}5\ Al_2O_3 : 34\ SiO_2$$

made with a lime frit, the following solution

10 gm. Manganese nitrate $[Mn(NO_3)_2 \cdot 6H_2O]$ in 5 gm. water
3·2 gm. Cadmium borotungstate $(2CdO.B_2O_3.9WO_3.18H_2O)$ solution with Sp. Gr. 3·28
3 gm. Sodium metatungstate $(Na_2W_4O_{13})$ in 3 gm. water

fired wet, painted over with concentrated manganate solution and fired again twice, produced a rose coloured tint under a glaze of the following composition:—

$$\left.\begin{array}{l} 0{\cdot}3\ K_2O \\ 0{\cdot}7\ CaO \end{array}\right\}\ 0.5\ Al_2O_3 : 4\ SiO_2$$

The red colour obtained with tungsten and manganese is due to the quartz.

Clay, silica and boric acid develop a yellow colour satisfactorily, whilst fluxes destroy it. In the writer's opinion, the formula $MnO : 0{\cdot}5\ Al_2O_3 : 1{\cdot}3WO_3$ should be used as the starting point for further experiments in orange colours, using iron and uranium for tinting purposes.

Orange is also produced with a solution of molybdic oxide when fired, and painted over with manganate solution and fired again. MoO_3 is a bright yellow, whilst MoO_2 is a deep black. The latter is formed in a strongly reducing atmosphere. Under a stoneware lead glaze blue colours were obtained with molybdate of ammonia.
The basic glaze

$$\left.\begin{array}{l} 0{\cdot}40\ K_2O \\ 0{\cdot}04\ MnO \\ 0{\cdot}06\ ZnO \\ 0{\cdot}30\ MgO \\ 0{\cdot}20\ CaO \end{array}\right\}\ 1{\cdot}5\ Al_2O_3 : \left\{\begin{array}{l} 3{\cdot}94\ SiO_2 \\ 0{\cdot}06\ MoO_3 \end{array}\right.$$

should give a good orange colour if applied in a layer of 1·5—2 mm. thickness to another white glaze.

PHOTOGRAPHIC TRACING PAPER, BLACK ON WHITE.—(*Sprech.*, **52**, 352, 1919). The following solution is applied to paper with a brush or small sponge:

Water	300	parts by weight
Gelatine	10	,, ,, ,,
Tartaric acid	10	,, ,, ,,
Iron vitriol	10	,, ,, ,,
Iron chloride	20	,, ,, ,,

The gelatine is first dissolved and the tartaric acid then added, and so on with each substance. When the paper turns light in colour the copy is ready for developing with

Water	500	parts
Gallic acid	5	,,
Oxalic acid	1	,,

PRINTING COLOUR FOR CERAMIC TRANSFERS.—(*Sprech.*, **52**, 352, 1919).

Powdered enamel colour	2—3 parts
Linseed oil varnish	4 ,,
Elemi	1 ,,
Storax	1 ,,
Turpentine	2 ,,
Poppy-seed oil	2 ,,

The whole is boiled in a water bath and stirred frequently, filtered through gauze moistened in turpentine and allowed to cool.

VIII.—COSTS, MANAGEMENT, ORGANIZATION, COMMERCIAL REPORTS.

SCIENTIFIC MANAGEMENT.—H. Schäfer (*Ker. Rund.*, **28**, 58—59, 1920). A discussion, with reference to present conditions in Germany, as to whether the introduction of Scientific Management, as a remedy for industrial unrest, is practicable at the present time. In view of the general attitude of the workers and the present legal position in Germany, the writer deprecates any attempt to introduce anything like the complete Taylor System into German industry. This will not be possible until normal conditions are restored and the mental attitude of the workers has undergone a fundamental change.

SIMPLIFIED SYSTEM OF COUNTING COST.—C. F. Mattes (*Brick*, **54**, 591—4, 1919). Discusses four elements of costs which have largely been lost sight of by brick manufacturers, viz.: depletion of shale fields, depreciation of plant and equipment, interest on investment and interest on finished stock inventory. (1) If the deposit is invoiced at £10,000 and will probably last 20 years, then each year there should be charged off 1/20 of £10,000, or £500. A corresponding depletion reserve should be set up in order that these charges may be anticipated. (2) Depreciation of kilns and depreciation of plant and equipment, for the sake of accuracy, should be dealt with separately, since the kilns depreciate much faster than plant and equipment. The item of depreciation is of the greatest importance, since it enables the property to be kept in first class condition without the necessity of having to appeal for fresh funds for renovation purposes. (3) Interest on investment charge has been a matter of argument for years in America. It is now recognised that, in order to secure a uniform system of costing for all concerns and an equitable basis for handling interest charges, it is imperative that interest computed on the total amount of capital invested (in plant, real estate, etc.), should be chargeable to manufacturing costs. (4) The finished stock inventory should be considered as so much gold. In costing, therefore, interest should be computed on the cost valuation of the average monthly inventory of finished brick, and charged to manufacturing costs.

Manufacturing costs might then be uniformly divided as follows:—

General Overhead Expenses ..	1. Office and Administrative Expense. 2. Fixed Charges. 3. General Expense. 4. Power Generation Expense.

Departmental Manufacturing Expenses ..	5. Clay Mining and Transportation Expenses 6. Processing and Machining Expense. 7. Drying Expense. 8. Transferring and Setting Expense. 9. Burning Expense. 10. Sorting and Drawing Expense.
Distribution Expenses	11. Rehandling Expense. 12. Selling Expense. 13. Renovation Expense.

No. 2 includes items 2, 3 and 4 above.
No. 5 ,, item 1 above.
No. 3, General Expenses, includes superintendence and factory clerical, general plant labour, stable expense, repairs to buildings, undistributed freight (incoming).
No. 11, Rehandling Expense, includes rehandling labour, straw used, freight charges (out going), local delivery.

SOME THOUGHTS ON PROFIT-SHARING.—(*Eng. Ind. Man.*, **10,** 295—6, 1919). A brief consideration of the question as to whether or not profit-sharing is likely to prove a panacea of all or any of the ills afflicting the industrial world.

It is observed that profit sharing, in the sense of deferred participation in profits, is advocated almost entirely by the employing classes. The reason is not far to seek. The average workman has little or no vision beyond the end of the week. To tell him that if he is careful and industrious he will have £5 given him in twelve month's time conveys little to him, and will not affect his conduct during the year in the least. What he wants is something he can feel and see here and now, and not a promise of something in the future. Again, the share of profits to be given to any individual workman at the end of the year is generally too small to influence him appreciably. In the case of a concern with a capital of £200,000, employing 400 workers, paying an average wage of £4 per week, and earning £25,000 per annum profit, if each worker is given a £50 share, bearing the same dividend as capital—say 10 per cent.—this would mean that the workers would hold £20,000 of shares and would draw £2,000 in all, or £5 each. To the average workman, the promise of such a sum would mean nothing. A rise in wages of 2s. per week would be infinitely more appreciated.

The Trade Unions have so far shown themselves very unsympathetic to any schemes of this kind. Profit sharing schemes tend to induce the worker to remain in his employment, at all events until the dividend is paid, and to make him disinclined to strike, especially on sympathetic grounds. They affect the solidarity of labour, and also the influence of the Unions.

Then there is the question, in what form the profit shall be credited to the worker. Most employers have a well-founded dislike to paying their men a lump sum in addition to their wages. They know only too well that it means a short week, with disastrous results to production. The writer's experience in connection with a War Savings Campaign showed that, unfortunately, most workmen cannot be relied upon to handle a lump sum of money in any profitable way. Some schemes have attempted to get over this by placing the dividend to the man's credit in a kind of Work's Bank, only to be withdrawn if he leaves, or is ill. But if a cash payment at the end of a year is unlikely to influence a man's work in the interval, the placing of the sum to his credit in a Bank is still less likely to do so. Again, the worker is prone to take the view that he has earned the money, that it is his property, and that he should do as he likes with it.

Then there is the vexed question of how the share of profit shall be allocated. Some firms pay it in proportion to the wages earned; but this is open to the objection that it favours a skilled but erratic piece worker against a steady and conscientious but less highly paid day worker. A

more frequent practice is to allot the shares to the workers on the lines mentioned previously. There are, however, many arguments against allotting ordinary shares for this purpose. If they are transferable in the usual way, the employees are liable to dispose of them for cash. Then there is the effect upon the market of the sale of such shares to be considered; in the case of strikes or lock-outs, they might be used for the double purpose of depressing the market value of the other shares, and of providing a fund for fighting the employers. Lord Leverhulme's view is that the best course is to give the workers non-transferable shares of a nominal amount which have no capital value, but merely entitle them to a proportional share in the profits. The writer sums up his own views on the subject in the statement that, in the present state of economic education of the workers, the only system of profit sharing which will have any practical results, is the payment of the profit week by week, preferably in some form of bonus, though there are certain special industries and classes of workers in which deferred profit-sharing may be advantageous to both employers and employed.

THE INFLUENCE OF HOUSING ON LABOUR TURN-OVER.—(*Eng. Ind. Man.*, **3**, 87, 1919). Housing and transportation have been found to be the most important factors in the turn-over problem, next to actual labour conditions within the factory. The housing problem has been widely studied in the U.S.A. and it has been shown that the solution of this problem will result in saving a large amount of money by the reduction or elimination of labour turn-over.

Capt. Boyd Fisher, of the Industries Board, in a paper entitled "Good Housing as a Reducer of Labour Turn-over," states that "it serves a manufacturer's strictly business interests to build houses for his workmen." The proof of this would be found in the record of companies whose labour turn-over had been reduced by the provision of sufficient and decent housing accommodation, as against those who had neglected the problem.

The U.S. Housing Corporation reports that "Employers interviewed without exception consider that housing shortage is a very important, if not the principal, cause of high turn-over." In one factory, employing many hundreds of men, the turn-over was found to be over 30% per month, and the company estimated that by solving the housing problem it would save £20,000 a year.

The actual operation of good housing conditions, as compared with poor housing, is illustrated in the blast-furnace section of Pennsylvania. One company had two furnaces about 20 miles apart, between which was the furnace of a rival company. The housing facilities of the first company are considered superior to those of the other, and it was found that for a number of years, the second company has had to pay all its men a higher rate per day for the same number of hours.

GAS VERSUS ELECTRICITY.—(*Eng. Ind. Man.*, **11**, 338, 1919) In comparing gas and electricity for heating, lighting and power, in an address before the Royal Society of Arts, Sir Dugald Clerk pointed out that the gas industry had nine times the capacity of the electric industry for heating, and that if the electric power stations were to take up the heating load of the gasworks it would entail the consumption of 58,500,000 tons of coal a year as compared with 10,900,000 tons used by the gas companies. The case was different for the production of light. The inverted incandescent gas lamp required 47 B.T.U. per candle power hour obtained. The one-watt electric lamp required 54 B.T.U., and the ½-watt lamp 31 B.T.U. A considerable proportion of gas burners consisted of the upright type, which was less efficient, requiring 82 B.T.U. per candle power hour. Thus the average might be taken at 64 B.T.U. From these figures it was evident that the competition between gas and electricity in lighting was very keen, and conditions other than heat economy would determine the system to be applied. The motive power position was much less complicated. At about 75 per cent. of full load as gas engine of the ordinary type would deliver to the consumer as actual or brake horse-power 11% of the heat used

at the gas works, while an electric motor would deliver, also as brake horse-power, only 6·8% of the heat used at the generating station. The efficiency of the gas power production and distribution was thus 1·6 times that of the electric system.

THE PRINCIPLES OF EMPLOYING LABOUR.—(*Eng. Ind. Man.*, No. 9, 273—276, 1919). The importance of the part played by the human element in industry cannot be too strongly emphasised, and it will seriously handicap British industry if it is ignored in the future. Few manufacturers, when requiring workmen, take the necessary trouble to ascertain the suitability of the man for the task for which he is required, with the result that the individual works unsatisfactorily and loses his employment, becoming a burden and a danger to the community. An improvement in the selection of workpeople would benefit both employer and employed.

The psychological problem naturally arises as to the correct methods to be adopted in judging the suitability of applicants for any particular class of work. The best method for popular psychological work is the division into contrasting tendencies so that a positive and a negative group are always confronting one another. It should first be decided whether a man is of a mental or manual type. Some would be unfit to become machinists or masons, though they might be excellent as designers or executives or leaders. Many, no doubt, are efficient in both directions. Then there is the settled and the roving type. The former likes the routine life, while the latter wants to move about and do new things. A third distinction is that betwen the indoor and the outdoor man. An energetic man, however strong his desire for an outdoor life, may have the energy to sit faithfully at a desk in a small office, but his psychophysical energies will be impaired and his efficiency wasted in spite of his best will.

Again, there are the directive and dependent personalities. The directive individuals naturally assume responsibility, while the others just as naturally evade it. The latter, however, must not necessarily be considered as of an inferior type of mind. The so-called dependant mind may produce much which the directive mind could not accomplish.

Some men like to give their attention to an intricate piece of mechanism, while others prefer only tasks of large dimensions.

Another group separates the adaptable and the self-centred personalities. There are men who very easily adapt themselves to their surroundings and become almost new men in new places, while others retain their strictly personal rôle in every new sphere of action.

Still more attention ought to be given to the difference between deliberate and impulsive men; the one carefully thinks out the situation before he acts, the other is quick at work, relying on his instinct, and profits little from quiet reasoning.

A further interesting classification is that of dynamic and static persons. The dynamic, a man with determination and grit, is the perpetual cause of changes; he looks steadily for improvements and is never satisfied. The static mind is conservative and is satisfied with the actual state of things because he is inclined to see the good in it. Both types have their important functions and may co-operate in the smallest as well as in the largest establishments.

It is a mistake to think of the labour supply as something tangible, that can and should be stabilised and brought to rest. We should rather consider it as a liquid, flowing sometimes in a destructive torrent, sometimes quiescent but seldom stagnant. Flow is necessary and desirable; without it progress is impossible, but the flow must be controlled.

In future, the "labour market" will have to be considered in every case when the site for a new industry is being selected, for labour has tasted the sweets of power and craves for more.

Certain fairly definite things tend to decrease the mobility of labour, such as the shortage of the purely labouring type brought about as a result of the war. Another important influence is the lack of versatility. The very decided specialisation of industry has brought a vast number of men

and women into our industries who know only enough to perform a single operation.

A cure for this lack of mobility of labour lies in the creation of a large reserve of men and women capable, because they know fundamental principles, of doing several things. Their training is the duty of the nation, because if they are to be mobile and able to equalise working conditions, they must be ready to go wherever the great demand exists.

As far as possible, the necessity for unskilled labour should be done away with. Loading and unloading wagons, for instance, or shovelling, seems a wilful waste when we know how to dump them by machinery. It seems wrong also to ask any man to lift burdens which might be raised by power; yet we have to admit that, for some time to come, we shall have mental defectives who are incapable of any mental effort above the lowest order. Works should be arranged, however, so that the percentage of such mental defectives is closely related to the purely labouring work to be done.

Expansion of business as a whole can only be accomplished by an increased amount of work done. It is, therefore, necessary to offer better opportunity to men to earn money. Every increase in opportunity to earn draws out a few more people who do not work when wages are low, because they work so slowly as to create an undue overhead charge. Every increase in the amount of work which is possible to place before workers in such a way that they can accomplish it, brings added production. Certain types of people, when offered overtime work, will overwork until they are worn out. These same people, offered larger wages for a given amount of work, will loaf part of the time, usually enough to secure about one-half the increase in wages.

The wise employer sees to it that every facility is offered his employees to work easily and effectively, and then sees that they are paid in proportion to the work done. Hours of labour are not so important as the question how tired the workers get during those hours. Daily hours should be such that, with the facilities offered, men can come to work the next day fully recuperated.

Undirected, men will more often than not do their work in ways which produce undue and unnecessary tiredness. Much of this can be remedied by study, to determine, for instance, whether the work is most easily and effectively done standing or sitting, whether changes in light help or hinder, etc.

THE WORKING OF A WORKS COMMITTEE.—Report of one year's working of the Work's Committee of the British Westinghouse Co. (*Eng. Ind. Man.*, **3**, 88, 1919). The idea of forming a Work's Committee developed out of a suggestion from a department that it should be made responsible for the care of a certain lavatory that had been closed because of damage done to it, and the malingering that had taken place in it. A deputation met the management, and it was agreed to set up a Committee to cover the whole works. The works were divided into 14 sections, each section having one representative. It was also decided that a representative of the management should sit on the Committee. The 14 representatives were elected by a meeting of delegates from all departments of the works.

After a time a number of rules were adopted for the guidance of the workers and their delegates. These rules were broad and elastic. Had the Committee surrounded itself with many rules and methods of procedure, it would not have been very effective in its work. At the outset, questions as to the general health conditions of the workers were taken up, and such matters as ventilation, draughts, fumes from furnaces, etc., were dealt with. An understanding was arrived at in connection with these matters, with the result that any complaint put before the Committee was always accompanied with a suggestion.

Many and varied questions were discussed and dealt with, among them: The provision of overalls at cost price, and an arrangement for paying for them by weekly deductions; improved tram and train service; hot

water in the mornings; ambulance equipment in different parts of the works; tea canteen; cycle sheds, etc., etc. A scheme has been adopted whereby a workman can bring forward an improvement, either to machinery or method of production, and have his interests safeguarded.

Departmental matters are dealt with by Sub-Committees, composed of the sectional representative together with the Chairman and Secretary. The Sub-Committee investigate any complaint, grievance, etc., and reports to the full Committee, and, if necessary, suggests a course of action. In large matters the Sub-Committee is elected from the full Committee, with a maximum of five members. Questions of bad time-keeping, wilful damage, pilfering, sleeping during work hours, etc., have been dealt with in an unorthodox manner, and very successfully.

From time to time, the delegates are called together in order to make them familiar with the work of the Committee.

Half-yearly reports are issued, and printed and typed notices are posted all over the works, to stimulate the workers' interest.

The value of the work of the Committee is shown by the fact that it has been accepted as an advice bureau on any and every subject connected with the workers.

HUMAN EFFICIENCY.—H. Chellew, (*Eng. Ind. Man.*, **1**, 1919). In modern industrial life no question looms larger before the investigating mind than the problem of human efficiency. The centre of gravity has shifted from money to man. The human factor presents a task involving vast research, patient and cautious investigation.

Work is fast becoming scientific, ceasing to be irksome, a task, and is seen in its true relation to human affairs. Life itself takes a new perspective.

The power of money, and the efficiency of mechanical inventions, have been amply demonstrated during the war, but no true definition of man power has yet been arrived at. No axioms are available to guide us in our research.

The modern industrial world presents a most complex field for investigation into the realm of human economics. The attempt at simplification in industry by the creation of trusts and combines, establishes no Utopia for the workers. Nevertheless, without men, there would be neither money nor machinery. Man power, the greatest power on earth, is not a constant, but a variable, but the results of investigation have yet to be simplified. The problem involves the physiological and the psychological sciences. With the former great results have been achieved in general human betterment, but much remains to be done in the domain of the mind. Modern industrial legislation has removed much of the hard character of the daily task—yet much escapes the eye of the Factory Inspector. Remuneration constitutes but one part of the reward of human endeavour. The employer is responsible in a larger, ethical sense for the happiness and general comfort of the employee. In industry and in commerce employers and employees stand or fall together.

Efficiency has been termed "the science of self-management." It is certainly not a mechanical thing; it is the science of life itself. The average man uses daily about 50% of his bodily power, and seldom more than 25% of his brain power. This constitutes a serious problem for the educationist.

Classical experiments on a large scale have been conducted in human efficiency, by the Cadburys, the Rowntrees, Lever Brothers, and others, and these have proved what can be done when the ideals of business management are identical and where employer and employee work as one. The restoration of the domestic spirit in industry has resulted in larger profits and wages and greater contentment. The labour leader of to-morrow will be the general manager of to-day.

The work of the pioneers, Taylor, Borth, Gautt, Hathaway, Gilbreth, etc., constitutes a body of teaching which has come to stay, despite opposition from Trade Unionism. These apostles of the new industrial era have fought well against those arch enemies of the human race, prejudice, tradition,

ignorance and selfishness.

The more important features of scientific management deal with the twin problems of Time and Motion Study, and Fatigue Study. In his investigations, Gilbreth, ably seconded by McKillop, concentrated on the elimination of avoidable effort. The analysis of such simple operations as folding a handkerchief revealed that there is a right and wrong way of doing most things, and further, it was demonstrated in the close study of bricklaying that, whereas formerly a man would lay 1,000 bricks per day, under this phase of scientific management, with brief instructions following upon a readjustment of tools and equipment, the same man could comfortably lay down 2,700 without any extra fatigue. Again, in the operation of shaving with an ordinary make of safety razor, by a close study of movement and of the instrument, the number of motions to get a perfect shave can be reduced from about 250 to 60.

No firm can hope to achieve perfection of product without devoting much attention to and spending considerable sums of money on the human plant. All money spent here is sound investment. Reduce the errors of the operatives in production and you soon discover where lies the secret of efficiency. This is the scientific way of reducing costs in increasing output. We have efficient machines and efficient systems of handling money, but only now are we seriously attacking the much more important problem of human efficiency.

In our investigations into the foundations of human efficiency, we very soon reach the problem of fatigue. The Industrial Fatigue Research Board confines its activities to this problem. In the domain of social and industrial science this marks the beginning of a new era in Great Britain, for hitherto most of the research work has been done in the United States. Such a body of eminent scientists, under the official ægis of the Government, and supported by the sympathetic interest of the captains of industry, will do more to ameliorate the lot of the worker in one decade than an army of agitators will accomplish in a century.

Fatigue may be generally divided into two aspects—mental and muscular. If we accept the axiom that "Society is an extension of the Individual" it is then obvious where we must begin research. Much may and does influence the life of the worker before he enters the factory. A man who has not slept well, or who has not had proper and sufficient food, cannot carry out his duties in a manner calculated to keep him constantly at his post. Housing and home life may be reckoned as remote problems, but we shall, nevertheless, not achieve our industrial perfection, until the State, through the Ministry of Health, concerns itself more with the welfare of its citizens.

Our educational system is pedantic and most inefficient. The relation of learning to earning is only now being realised in its true sense. A bridge must be built from the school to the factory, and in Vocational Training and Guidance, must be found the solution to one of the most urgent questions of the day.

The Factory Inspector has been the guardian of the best interests of both employer and employed, but the Welfare Supervisor will add strength to our collective attempt at improving and humanising the daily task. Such problems as Air, Light, Sanitation, Canteens, Recreation, the provision of Rest Rooms, First Aid, etc., will go far in making the hours in the factory as congenial as the hours outside. Fatigue is the parent of industrial unrest and social discontent. The work card setting out the task after research by the expert in Time and Motion Study, will not be looked upon as a sentence, but as a challenge to newer and better methods of work.

All this, however, cannot be anticipated without the willing consent of the worker, and a corrected mental attitude on the part of organised labour. Propaganda must be undertaken in this field by anyone whose object is to make work within the factory conducive to health and happiness.

The provisions of all Acts dealing with employers' liability will lose some of their terrors when the worker takes a greater interest in his own

welfare, and a deeper interest in his work.

INDUSTRIAL ACCOUNTING.—L. R. Dicksee, M. Comm. (*Eng. Ind. Man.*, No. **2**, 39—41, 1919). The importance of adequate accounting as a factor in industrial success is not yet sufficiently appreciated.

In its development, industrial accounting has not kept pace with other branches of industry. Instead of tuning up accounting to face the new conditions, the industrial accountant of the day has evolved, by the simple process of shirking, that abomination known to the present day as "single-entry book-keeping."

A really adequate Accounts Department is essential to the proper management of industrial concerns. Nothing new in this direction, however, should be undertaken without a careful consideration of practical details and without the advice of a competent expert.

To deal with the vast amount of detail, organisation, standardisation, and the intelligent employment of machinery are as necessary for the adequate control of the accounts as in the factory.

Old fashioned book-keeping consists of making a careful record of things that have happened and of copying by hand precisely the same information several times from one book to another, involving loss of time and money, in addition to the risk of errors in copying. Modern methods of accounting, on the contrary, aim at making the original record in such a way as to obviate the necessity of subsequent copies by hand. This is done by substituting mechanically made copies—usually "carbon" copies. This arrangement tends to reduce costs, speed up results, and ensure accuracy, and its operation need not necessarily be limited to the Accounts Department proper. Thus, the same recorded particulars of an Order received may in some cases develop naturally into a Works Order, a Works Cost Sheet, a Delivery Note, a Customer's Invoice, a Ledger Debit Note, and a Sales Analysis; an acknowledgment of a customer's remittance may develop into a Cash Book Entry and a Ledger Credit Slip; while a Stores Requisition may with equal facility develop into a debit slip for materials used and a credit slip against the corresponding Stores Account. It is also possible, if desired, to carry the matter still further, and to arrange a definite system of filing first-entry slips so as to eliminate all postings connected with Ledger Accounts. A system which has been in actual use for several years past is described in the writer's book, "Office Machinery and Appliances."

Attention is drawn to a new automatic Book-keeping Machine which types ledger postings, while keeping tally of the amounts so posted, thus enabling the accuracy of the postings to be determined with mechanical certainty. The working cost of such a machine represents approximately an outlay of half-a-guinea a week, but its employment will enable any ordinary ledger keeper easily to double his (or her) output. It may also be mentioned that it is far more difficult to manipulate figures in a typed ledger than in a ledger written by hand.

Most manufacturers are probably now familiar with the advantages of a card system, applied to records of workmen's time, as compared with the old-fashioned time sheets which have to be analysed afterwards. Apart from the fact that cards readily lend themselves to a system of "clocking," the card idea, once adopted, enormously reduces the number of ledger postings involved, by the simple process of sorting cards into groups according to subject matter, and arriving at their aggregate effect by means of some form of adding machine. It is accordingly now possible to book all workers' time against the proper accounts, whatever they may be, and to balance the time so booked against the time that has to be paid for, before wages are paid, and that without any increase in the time between the making up of the time and the hour of paying wages. Formerly, any work in connection with the allocation of workers' time was invariably done after the wages had been paid, when it was too late to deal effectively with any queries that might arise. The National Insurance Act has necessarily added to the complexities of the ordinary factory Pay Roll, as a result of which it would probably be

considered quick work to build up a Pay Roll at the rate of 50 workers per hour. By the intelligent use of office machinery, however, a far less skilled worker can construct Pay Rolls in precisely the same detail at about eight times the pace, with the absolute assurance that all additions are free from the possibility of human error.

Another modern labour-saving device is the Voucher System, as a result of which the Bought Ledger Accounts are abolished entirely. In place of the old-fashioned system of elaborately entering up invoices in a Purchase Book, and posting thence to Bought Ledger Accounts, the invoices are filed away under their proper headings as soon as they have been certified as correct. When a demand for payment is received in the form of a monthly Statement, the certified invoices necessary to vouch this Statement are turned up and attached to it; whereupon the Statement is certified as an Account Payable, upon a form which indicates precisely what accounts are to be charged with the expenses involved. The Certified Account then comes before the Cashier's Department: (*a*) as an account to be paid; (*b*) as an outlay to be charged up under certain specified headings. This system not only cuts out a considerable volume of needless accounting, but also ensures all outlay being charged under the proper headings. The full extent of outstanding liabilities can be ascertained from the corresponding files probably more rapidly than by the old process of extracting from the Bought Ledger. Sectional balancing is also just as readily provided.

But the limitations of industrial accounting have hitherto been most marked in the almost complete absence of any satisfactory attempt to keep accounts continuously recording movements of stores of raw materials or Working Costs. This in the writer's opinion, will continue to be so, as long as the Accounts Department is compelled (*a*) to keep all its records in bound books; (*b*) to make all its records by hand. Under the new conditions, the process of posting to Ledger Accounts is readily shorn of all risks of inaccuracies, and may be speeded up anything from 100 to 1,000 per cent. If the transactions involved are not very numerous—*i.e.*, do not run into many thousands, the simplest way may be in the first place to sort out the slips of original entry into heaps or groups, according to the accounts concerned, as indicated by distinctive numbers on the forms, afterwards to list each group of forms upon an adding machine, and then to post the ultimate totals (daily, weekly or monthly) to ledger accounts kept on conventional lines. If, however, the entries are really numerous, as they very easily may be, an invaluable time-saver is provided by the Hollerith Machines. Each separate transaction is punched upon a separate card, an operation that can easily be performed by girls who have just left school at the rate of 250 to 800 cards per hour according to the degree of detail. Cards so punched are then mechanically sorted at the rate of 15,000 per hour per operation, and, having been sorted, the contents of any desired group may be tabulated upon another machine at the rate of 9,000 per hour in any desired number of columns according to the size of the machine. Thus, one set of Hollerith Machines, with a comparatively small and inexpensive staff, will readily and accurately perform work which would probably occupy at least 15 or 20 trained book-keepers. Even more important is the fact that the Hollerith produces its results quickly. By its aid it is not only possible to obtain monthly costs sheets by the middle of the following month, but in some cases, Costs are actually available for managers before the wages to which they relate have been paid.

The essential requirements of every system of costing, particularly of every accounting system for industrial use, are: (1) That it should produce results; (2) That it should keep down costs; (3) That its employment should make for general peace all round. There can be little doubt, however, that, in industrial accounting, as in industrial production, these results are not generally obtainable without the use of suitable machinery. For industrial purposes, at least, accounts are required that must be "news," not "history." No Management can be good that is not backed up by good accounting, for, without it, Management must necessarily be working very

largely in the dark, and without proper guages.

MANUFACTURING COSTS IN THE GLASS INDUSTRY.—J. D. Mills (*Eng. Ind. Man.*, **3**, 82—84, 1919). A costing system serves the following purposes: (1) To regulate selling prices according to cost of manufacture; (2) to frame estimates and tenders; (3) to locate non-paying lines or departments; (4) to establish a standard of costs for stock purposes; (5) to detect waste and deficiency; (6) to keep each element of cost under observation.

The secret of the success of a system is to ensure that ordinary book-keeping methods are planned to assist with costs, and the idea that the introduction of a costing system means a huge increase in clerical staff is entirely erroneous. On the contrary, it is sometimes discovered that much time has been wasted in keeping unnecessary accounts.

The elements of cost may be summarised as follows:

1.
Direct charges or Prime Cost.

(*a*) Direct Wages	(*b*) Direct Material	(*c*) Chargeable Expenses

2.
Indirect charges or On Cost.

(*a*) Indirect Works Expenses	(*b*) Indirect General Expenses

The total of 1 and 2 gives the Gross Cost of Production.

Mr. J. D. Mills, chief accountant to the Glassware Department of the Ministry of Munitions, who carried out investigations in all sorts and sizes of factories, advocates the theory that Direct or Productive Wages form the most steady element upon which to apply On Costs. At intervals, Profit and Loss and Trading Accounts should be prepared from the general books to provide a means of verifying or correcting the existing On-Cost rates.

It is most important that the cost of making the glass should be ascertained quite separately from the labour cost of blowing or any subsequent operations. The elements of costs of making glass may be tabulated thus:

1. Batch (including carriage).
2. Mixing cost.
3. Furnace charges.

The cost of Batch is determined by taking the various chemicals, etc., according to formula and pricing them at current rates. In some instances it may be desirable to work upon the total quantity of new batch consumed in a given period, whilst in others it will be more convenient to base the calculation on the cost per lb.

Mixing cost includes wages of mixers; cost of sand burning, crushing, grinding and storing in bins; repairs and renewals to machinery and mixing plant; motive power; lubrication, etc. It would be applied on the same basis as Batch, and new batch only should stand the cost of mixing, as created cullet is not subject to further mixing.

Combining the two factors, Batch and cost of Mixing, the cost of Mixed Batch is arrived at; this is subject to further adjustment before the cost of Batch in melted glass is obtained. In the following illustration the percentages are fictitious; in actual practice they would, of course, be determined by the competent technical man.

Assuming that mixed batch weighing	1 lb.	costs 2·694 d.
Shrinkage of weight by moisture in purchased sand, etc., wastage in transit reduces weight by 10%	·1	
Dry batch ready for fusion ..	= ·9 lb.	costs 2·694 d.
Loss in fusion by gases, etc., 10%	= ·09	
Melted glass in pot or tank	= ·81 lb.	costs 2·694 d.
Loss by volatilisation, proofs and skimming, 10%	= ·081	
Batch in workable glass ..	= ·729 lb.	costs 2·694 d.

Therefore the batch in 1 lb. of workable glass costs 3.695 pence.

With regard to Furnace Charges, where more than one furnace is installed, it is advantageous to keep the cost of working each furnace separately, as one furnace would probably be more expensive to work than another. The total cost of working Lehrs, Glory-holes, Pot Arches, and Smithy could be regarded as part of furnace charges, but it will be better to separate them, if possible, as it is incorrect to saddle articles with such costs if they did not call for Lehr or glory-hole treatment. Furnace charges might be allocated under headings such as the following:—

TOTAL	No. 1 Furnace	No. 2 Furnace	Main Lehr	Re-Annealing Lehr

The various items to be regarded as Furnace Charges are:—

Wages of engineers, bricklayers, labourers, claymen, Lehr attendants, smithy men and stokers; cartage charge for removal of clinkers;
Fuel consumed, including cartage;
Pots (or clay where pots are made on the premises) including carriage;
Firebricks, Fireclay, "Korktite," Bricks, Tiles, etc., including carriage;
Clay rings and pot sundries;
Repairs and Renewals to fire irons, bars, blowing irons, etc.
Repairs and renewal to furnace or tank.
New moulds and repairs thereto.
Oil, carbon, etc., for glasshouse use.

Should a departmental system of costs be used, it would also be possible to absorb in furnace charges such items as Rent, Rates, Taxes, Depreciation, etc., applicable thereto, and thus reduce the expense that has in a general way to be charged as On-Cost.

Having determined the furnace charges in total, it is quite simple to convert it into a unit such as cost per week, per tank, per pot, etc. By dividing the cost per unit by the corresponding output of such unit, the furnace charges to be borne by the output are obtained. Assuming that the output is expressed in lbs. as in the case of Gauge Glass Tubing, the resulting figure is the cost of Furnace Charges per lb., and as the cost per lb. of batch in workable glass is already determined, the total of these two items produces the cost of workable glass per lb.

If operations subsequent to blowing are performed, the cost of glass per lb. in the finished articles can be determined by the following formula:

$$\text{Cost of mixed batch in workable glass per lb.} + \frac{\text{Furnace Charges per Unit.}}{\text{Output per unit in lbs.} \times \text{Percentage reaching Store after all operations.}}$$

Where varied articles are produced from a pot or other unit, and it is impossible to arrive at the output of such unit, it will be necessary to theorise the output on the lines of the following formula:

Cost of mixed batch in workable glass per lb.	+	Furnace Charges per Unit: Quantity of batch put into pot or tank (A)	×	Percentage of weight surviving fusion (B)	×	Percentage worked from Pot or tank (C)	×	Glass in goods / glass gathered (D)	×	Percentage reaching store (E)

(A) The total weight of batch should be readily obtained.
(B) Weight lost in fusion is dealt with under batch.
(C) The percentage worked from a unit could be reasoned with the assistance of the technical expert, or from practical experience.
(D) The ratio of glass in goods to glass gathered can be established on the following lines:—

(x) weight of finished article	=	2·5 oz.	=	25%
portion cut or worked off	=	5·4 ,,		
(y) weight off blowing iron	=	7·9 oz.		
(z) weight left on blowing iron	=	2·1		
.. weight gathered	=	10·0	=	100%

The factors x, y and z are all ascertainable from practical experience.
(E) The percentage reaching the store can be figured as follows:—

Article	No. Blown	No. Surviving Lehr	Loss between Operations	Percentage reaching Store
—	100	90	12·5% × 90 = 11·25	78·75

Dealing with the subject of Labour Charges, Mr. Mills pointed out that labour is either productive or unproductive. Unproductive labour should be charged to the indirect expense account of the department, to be treated as on-cost against that department. A Shop foreman's time should be handled in this manner, necessary idle time through stoppages, etc., similarly.

Piecework eliminates unproductive labour as far as operators are concerned, and when time work on hourly or weekly rates is in force, the time should be recorded on time sheets or books, so that it can be properly analysed in the main wages book. These time sheets should be designed to record the articles commenced and the number completed, which latter has to bear the labour cost of the total commenced. It will also furnish the percentage of loss between operations, an important factor in assessing the cost of glass in finished articles, in addition to figuring the breakages, loss of labour between operations, as illustrated in the following:—

BREAKAGE LOSS OF LABOUR BETWEEN OPERATIONS.

Operation	Labour Cost of Operation	Cumulative Labour Cost	Loss %	Loss in Pence
	d.	d.		
Blowing	30·66	30·66	—	—
Cutting off	1·64	32·30	2·96	1·01
Grinding	10·56	42·86	3·85	1·24
Washing	1·26	44·12	·87	·37
Examining	·88	45·00	4·59	2·03
Papering	·28	45·28	·23	·10
		Total ..	12·50 per cent.	4·75 pence

The breakage loss of labour between operations is determined by figuring the loss per cent. at any stage upon the accumulated labour cost up to the previous stage, as the cost of any one operation is absorbed by the surviving quantity throughout.

As much indirect expense as possible should be absorbed in the expense account of the department concerned, thus reducing the amount of on-costs

to be applied generally over the whole of the firm's operations. Rent, rates and taxes may be readily allocated on the basis of floor space occupied and depreciation could be easily charged against the plant concerned.

Such charges as cannot be allocated to particular departments have to be dealt with as a general on-cost percentage, to be assessed on the productive labour involved in the manufacture of the article under consideration. The following summary enables us to arrive at the selling price by adding to the gross cost a percentage of profit, a question entirely for the decision of the management.

	Material	Productive Labour	Deparmental On Costs
	Pence	Pence	Pence
A. Cost of glass, including batch, furnace charges, lehrs, "glory-holes," pot arches, smithy work per formula: 8 lbs. at 10d. per lb.	80.00	—	—
B. Blowing (labour)	—	20·00	10·00 50%
C. Cutting off (labour)	—	7·00	·70 10%
D. Grinding (labour)	—	10·00	1·00 10%
E. Washing (labour)	—	2·00	·10 5%
F. Inspection	—	5·00	·50 10%
G. Papering (labour)	—	·50	·05 10%
H. Breakage, loss of labour and departmental on-costs between operations ..	—	4·75	·475 10%
	80·00	49·25	12·825

Works Cost	142· 075
Add General On- Costs (25% on productive labour)	12·3125
Gross Cost	154·3875
Add 20% profit	30·8775
Selling Price	184·2650

SCIENTIFIC RESEARCH IN RELATION TO THE CERAMIC INDUSTRY.—V. Bodin (*Cer.* **386**, 55, 1920). An article urging the adoption of scientific methods in all branches of the industry. For this purpose, the writer considers that every concern of any considerable size should have its own laboratory with a thoroughly experienced staff, and that, by a system of grouping, the smaller enterprises might enjoy the advantages of a joint research department. To meet the vast change in industrial circumstances which has taken place since 1914, organisation of management on the Taylor system, or something similar, coupled with organisation of the methods of production based on scientific research, is absolutely indispensable.

THE RÔLE OF THE CHEMICAL ENGINEER IN THE REFRACTORY INDUSTRY.—W. B. Scheid (*Tonind. Ztg.* **43**, 818, 1919). The co-operation and assistance of highly-trained experts to meet the requirements of modern industry, are becoming of greater necessity from day to

day. The days of the old practician are over. The writer pleads for the fuller recognition of the valuable services rendered by the technical and scientific expert.

THE TAYLOR SYSTEM.—Anon. (*Tonind. Ztg.* **43**, 825, 1919).

REPORT OF A VISIT BY M. V. BODIN, TO THE CENTRAL SCHOOL OF SCIENCE AND TECHNOLOGY, STOKE-ON-TRENT, APRIL 13TH AND 14TH, 1920.—(*Cer.* **388**, 108, 1920).

THE MANUFACTURE OF MODELS IN NEW WORKS.—E. Motschmann (*Sprech.*, **52**, 128, 1919). A few hints as to the method of procedure. The shrinkage of the different bodies must first be very carefully measured. A sort of scale can then be prepared in the form of an isosceles triangle, one side of which represents the height of the largest object to be made in any particular body, and the base measuring the height of the same object after firing. The corresponding sizes of other objects of the same body can then be readily determined.

ECONOMIC PRODUCTION IN THE CERAMIC INDUSTRY.—(*Sprech.*, **52**, 2, 7, 1919). An appeal for the introduction of more economic methods of production in the Ceramic Industry, such as specialization by product and by process, more extensive and economic utilization of modern machinery, and less wasteful employment of man-power, etc. Although, as compared with the engineering industry, the problem facing the Ceramic Industry is much more complicated owing to the necessary consideration of such matters as, for instance, the almost constant demand in the market for new forms and designs, etc., yet there is ample scope for improvement in the way of simplified grading, greater uniformity in production, etc. The introduction of "novelties," with its consequent loss to productive power, should be discouraged, unless it can be shown unmistakably that the new form is a decided improvement from the point of view of usefulness or technical and artistic value.

GERMAN INDUSTRY AND THE WAR.—R. C. P. Jaureguy, H. B. Froment, and R. E. Stephen (*Chim. Ind.*, **1**, 27E=159, 1918). A comprehensive review of past, present, and futute of German industry in general, including references to combustibles, metals, raw-materials. Interesting details are given concerning the Liebig Scholarship Association (for the training of Chemists, etc.)

DECIMAL CLASSIFICATION.—C. Matignon (*Chim. Ind.*, **1**, 1918). A review of the general system of decimal classification based on principles laid down by M. Dewey. It is inserted at the end of the volume.

CAN THE TAYLOR SYSTEM BE INTRODUCED INTO THE CERAMIC INDUSTRY?.—O. Wilhelm (*Sprech.*, **52**, 286, 1919). The German workman since his recent emancipation has become even more unsympathetic towards all methods of scientific management, and more suspicious of any attempt to introduce them, than was formerly the case. The writer is convinced that the American system cannot be simply applied *en bloc* to German conditions. To restore the nation's industrial efficiency, however, there should be no delay in introducing scientific principles wherever possible. Success would depend upon united action between manufacturers, workers, dealers and consumers, who would all share the advantages of the new system. The matter deserves the whole-hearted support of the State and of the community.

X.—GLASS.

CZECHO-SLOVAK GLASS SITUATION.—(*Chem. Met. Eng.*, **23**, 57, 1920). A short, general account of the industry which at the present time is in a flourishing condition. The present monthly production amounts to 25,000 metric tons, with prospects of reaching 35,000 tons in the near future. Eighty per cent,. comprising household goods, cut glass, lamp chimneys, bulbs, etc., has been exported. New concerns have been organised with large modern plants.

The window, mirror and photographic glass industry, comprising 29 factories, are operating at 75% of their capacity; 85% is exported. Seventeen factories making all varieties of bottles are working at 35% of their capacity. Coal, soda and potash are available only in limited quantity. There are 156 factories in all; 15 use wood fuel only; 21 use wood and coal. Soda and potash must be imported in large quantities from Germany and Austria.

SURFACE OF GLASS PLATES.—J. Nakazawa, Matsuo Fukui and K. Ueda (*Jour. Tokyo Chem. Soc.*, **40**, 821, 1919). The phenomenon of "cloudiness" so often observed in mirrors is discussed. Photomicrographic examination of cloudy mirrors revealed a network of spots. The cause of cloudiness is concluded to be due to the presence of these spots. The microscopic network of spots is visible only with a reflected light, but when illuminated by light with certain angles of inclination in a dark field, bright particles can be seen at the same spots. The size and mode of distribution of these particles have much to do with the quality of the glass. The higher the grade of glass, the more compact, uniform and the smaller are the particles. Experiments showed that these spots are not caused by dusts, condensed water, microscopic foam or minute scratches on the surface, but exist upon as well as within the surface. The speed of cooling the glass affects the size of these particles, suggesting very strongly their crystalline nature. The authors conclude that they are granules formed at the time of solidification much in the same manner as crystals.

REFRACTORIES FOR THE GLASS INDUSTRY.—(*Chem. and Met., Eng.*, **23**, 304, 1920). The American Bureau of Standards has commenced an investigation with the object of developing improved refractories for making pots, etc., for the glass industry. A systematic study of bodies composed of siliceous bond clays with aluminous grog and of aluminous bond with siliceous grog is being conducted. Crucibles have been made of these mixtures, and after firing, the action of corrosive barium glass will be noted.

GLASS TANKS WITH SPECIAL "WORKING-OUT" TUBES.—H. Knoblauch (*Sprech.*, **52**, 311, 1919). The chief characteristic of this style of furnace is a sort of "knee-shaped" tube, made of refractory material, which extends to a certain depth into the molten batch. The molten material entering the tube from below can then be worked out, whilst the new batch is introduced outside the tube. The article is illustrated.

SILVERING OF GLASS.—(*Sprech.*, **52**, 78, 1919). Taken from A. Silverman's and P. D. Neckerman's paper in *Trans. Amer. Cer. Soc.*, **17**, 505, 1915. (See TRANS. **16**, Abs. 29, 1916).

ECONOMICS IN THE GLASS INDUSTRY.—H. d. B. (*Sprech.*, **52**, 269, 1919). A few hints (with sketches) as to how certain economics may be effected, with particular reference to tank construction.

CARBON-YELLOW GLASS.—L. Springer (*Sprech.*, **52**, 88, 1919). An account of various experiments and investigations to prove that carbonaceous matter, not only in conjunction with sulphur containing materials. but also of itself, is capable of imparting a faint yellow tint to glass.

THE MANUFACTURE OF GLASSES FOR CLOCKS, ETC.—(*Sprech.*, **52,** 277, 1919). Any ordinary crystal or half crystal mixture is suitable, as for instance:

	Ordinary Crystal.		Half Crystal.	
Sand	100 kg.	100 kg.	100 kg.	100 kg.
Soda	10	14	8	10
Potash	25	20	26	26
Calcareous spar..	20	16	15	10
Carbonate of Barium	20	—	—	10
Red Lead ..	—	—	14	10
Nickel oxide ..	—	0·04	—	—
Manganese dioxide	0·2	—	0·2	0·2

The size of the spheres blown (30 to 100 cm. diam. or more) depends on the desired thickness and degree of convexity. The rough cutting is done on a table covered with velvet. The individual glasses are finished in a hollow block of wood lined with velvet.

QUARTZ GLASS IN THE CERAMIC LABORATORY.—H. Tafner (*Sprech.*, **52,** 257, 1919). Though widely used for general laboratory purposes, quartz glass has no special value for ceramic work. Quartz cannot replace platinum or grog in the manufacture of crucibles. Opaque quartz-glass, though made of the same material as the transparent variety, is full of innumerable minute air-bubbles, which are cut through upon grinding the glass, leaving an uneven surface. Vessels of this material are, therefore, difficult to keep properly clean. The translucent variety of quartz-glass also contains minute air-bubbles, but in far smaller numbers. It is, therefore, more suitable than the opaque for laboratory purposes, and it is cheaper than the transparent variety.

CASTING THIN PLATEGLASS.—(*Sprech.*, **52,** 226, 1919). Two processes are briefly described, viz.: the Herzogenrath and the so-called $\frac{3}{4}$ white. In the former process, large pots, together with the usual equipment for casting thick glass, are employed with the necessary modifications in the size of the casting tables, rollers, etc. Sheets of from 50 to 60 sq. m. and about 7 mm. thickness are cast; they have to be cut up while warm to enable them to pass into the cooling chambers. Grinding and polishing are carried out in the same manner as for thick glass. In the $\frac{3}{4}$ white method, a number of small pots are used, each containing sufficient glass to make a sheet of 4 to 10 sq. m. of 7 mm. thickness. Normally, one casting in the Herzogenrath process, and two castings in the $\frac{3}{4}$ white, are made every 24 hours. The advantages of casting thin plateglass include: elimination of the labour of the glass blower and the plate glass maker; as compared with the blowing process the coal consumption is as $1:1\frac{1}{2}$ to 2. In comparison with the $\frac{3}{4}$ white method, the Herzogenrath process has economic advantages which more than counterbalance the higher initial outlay on plant.

GLASS POT MAKING.—O. Schrenk (*Sprech.*, **52,** 220, 1919). A short, general account of the conditions in the pot shop, with hints as to the necessary precautions to be taken as regards temperature, drying, preparation of the body, etc.

COOLING OVENS IN BOTTLE FACTORIES.—(*Sprech.*, **52,** 211, 1919). An appeal for the extensive introduction of the Owen's system. A method is described and illustrated of constructing branch tunnels, where sufficient room is not available for one straight length.

A NEW METHOD OF COVERING GLASS BEADS.—O. Parkert (*Sprech.*, **52,** 191, 1919). A short description of a method for lining beads with so-called "fish-silver" so as to preserve the brilliance of the outer glass surface. The "fish-silver" solution is a rapid-drying mixture of dry fish-silver, copal varnish, mastic and acetone. Pure fish-scale silver must be used; substitutes such as alumimium bronze give a dirty white appearance. The beads are thoroughly cleansed with soda-lye, and dried. They are then

placed in the silver liquid in a flask attached to a revolving drum. The flask is closed with a rubber stopper and the machine set in motion. After a short time, the liquid is found to be evenly distributed over the inner surface of the beads. Usually, a small globule remains inside each bead; this can be removed by gently heating over a small flame whilst the container is revolved at double speed. The solvent is then rapidly volatilised, and at the same time a fast lining of silver is procured. Any silver adhering to the outer surface of the beads is then rubbed off. Aniline colours, lustres, etc., can be applied in the same way. For buttons and other small objects the container is in the form of a cylinder, provided with sockets to enable a sieve of corresponding shape to be fitted inside it. The articles are placed in this sieve, which remains stationary whilst the container revolves, or *vice versa*

A NEW METHOD OF CLEARING REGENERATORS.—J. Baldermann (*Sprech.*, **52**, 149, 1919). To facilitate clearing of the regenerators, the bricks may be introduced on small iron trolleys, with perforated bottoms. These trolleys are run into, and out of the chambers (there are two in each) on rails. Another source of trouble in glass furnaces—the penetration of hearth glass into the regenerators—can be avoided by constructing the latter far enough on either side so that no part of them lies underneath the furnace.

REPLY TO ABOVE.—M. Reiboldt (*Sprech.*, **52**, 180, 1919). The writer characterises the two methods indicated in above abs. as neither new nor practical. The guarantees for a good working, economical fuel consumption and a satisfactory product, are—close proximity of the regenerators, the base of the furnace must be properly constructed, of good material, timely removal of the hearth glass, etc.

A GLASS-BLOWER FOR DEMIJOHNS AND ACID JARS.—(*Sprech.*, **52**, 96, 104, 1919). A description, with sketches, of a machine constructed by I. Rau, of the Fairmount Glass Works, Indianapolis, for blowing demijohns, etc.

GRINDSTONES FOR GLASS.—(*Sprech.*, **52**, 63, 1919). Deals with the problem of finding substitutes in Germany for the material formerly imported from England and Lorraine.

MANUFACTURE OF GLASS POTS IN ENGLAND.—(*Ker. Rund.*, **28**, 153, 167, 190, 215, 1920). Articles taken (with illustrations) from a paper by B. J. Allen, in the "British Clay Worker."

THE NATURE AND DURABILITY OF GROG-BRICKS IN GLASS TANKS.—J. Baldermann (*Sprech.*, **52**, 285, 1919). The coarse-grained, porous grog bricks are easily attacked and destroyed by the liquid glass, particularly sulphate glass. The top part of the tank should, therefore, be made of the same material as glass pots. The life of a tank can thus be doubled at a comparatively small increased cost.

THE PROPERTIES OF THE LIME-SODA GLASSES.—J. H. Davidson and W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 222, 1919). Hitherto, commercial lime-containing glasses have usually been found to be successful if their composition can be expressed very nearly by the formula 6 SiO_2, CaO, Na_2O, in which the proportions of lime and of soda may be varied providing there are always three molecules of silica to one molecule of the lime and soda combined.

Thirteen glasses were studied, containing respectively 2·0, 1·9, 1·8, 1·7, 1·6, 1·5, 1·4, 1·3, 1·2, 1·1, 1·0, 0·81, and 0·75 molecule Na_2O, with CaO (except for the first) to make up 2 molecules altogether. The first eleven had 6 SiO_2, the next, 3·94 SiO_2, and the last 4·63 SiO_2; the last two were commercial glasses used for making bottles. The chemical composition (per centage) is given, and also remarks on working properties. Lime-containing glasses have usually been regarded as readily devitrified, but in this series devitrification took place less and less readily as the amount of lime increased, and was least in the last two, which were richest in lime.

All glasses of composition 1 to 6 should be avoided, but from 7 onwards there is a general improvement, and glasses 7 to 11 are all durable. For semi-automatic machines, and for pot metal, glasses 7 to 9 will usually be found satisfactory, whilst the succeeding four are more suitable for working in tanks operated by hand labour.

DURABILITY OF LIME-SODA GLASSES.—J. D. Cauwood, J. R. Clarke, C. M. M. Muirhead, and W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 228, 1919). Relates to investigations on the action of water, hydrochloric acid, caustic soda, and sodium carbonate on glass. It is deduced from the results that glasses with composition between those of 1 to 6 (in preceeding abstract) should be avoided, as they are too readily attacked by the reagents named, and are also hygroscopic. Gradual substitution of soda by lime in a glass batch makes a glass much more stable to all kinds of liquids with which the vessel may be filled. In the glasses which contain only a very small amount of lime, water is the most corrosive agent, and strong caustic alkali the least corrosive. From the point of view of fairly rapid melting, and of producing a soft glass for automatic or semi-automatic machines, glasses 7 to 9 may be considered as satisfactorily durable for common use.

HEAT EXPANSION OF SODA-LIME GLASSES.—S. English and W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 238, 1919). From results of tests, the authors conclude that in a series of lime-soda glasses of generally similar type, the variation of the composition and the coefficient of expansion are related to one another in a simple additive manner, and that those with highest soda content have the greatest rate of expansion, reduction of expansion occurring with successive increase in the lime content and diminution of soda. It is also concluded that Schott's factors for the calculation of coefficients of expansion contain considerable errors.

MANUFACTURE OF TABLE WARE IN TANK FURNACES.—R. L. Frink (*J. Soc. Glass Tech.*, **3**, 242, 1919). A discussion of the difficulties to be surmounted, and the way to meet them. The paper concludes with a summary of the conditions essential to successful glass melting.

PROPOSED STANDARD FORMULA FOR A GLASS FOR LAMP-WORKERS.—F. W. Branson and F. H. Branson (*J. Soc. Glass Tech.*, **3**, 249, 1919). Relates to a glass composition based on analysis of a satisfactory pre-war imported tubing. The new glass, as made in experimental batches on a manufacturing scale, proved to have very satisfactory properties.

GLASS FOR TABLE WORKING.—M. W. Travers (*J. Soc. Glass Tech.*, **3**, 253, 1919). A short note containing a few data concerning some special glasses.

THE POLARISCOPE AND ITS APPLICATION TO THE GLASS INDUSTRY.—G. V. Wilson (*J. Soc. Glass Tech.*, **3**, 256, 1919). A short article explaining its use for detecting strains in glass.

SIMPLE APPARATUS FOR THE DETECTION OF STRAIN IN GLASS.—S. English (*J. Soc. Glass Tech.*, **3**, 258, 1919). A device for detection of bad annealing.

NOTE ON THE FORMATION OF GLASS.—S. C. Bradford (*J. Soc. Glass Tech.*, **3**, 282, 1919). A theoretical discussion, based on the hypothesis that glass has the nature of a gel.

INFLUENCE OF LIME ON THE VALUE OF YOUNG'S MODULUS OF ELASTICITY FOR LIME-SODA GLASSES.—J. R. Clarke and W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 260, 1919). As a result of a series of measurements on thirteen different lime-soda glasses of regular variation in composition, it has been shown that:—(1) The regular increase in the amount of lime present causes a continuous and very marked increase in the elasticity of the glass. (2) The conclusions of Winklemann and Schott, which suggest that lime and soda are but little different in their effects on

the elasticity, are incorrect. (3) New factors were derived by which it was possible to calculate the elasticity of a simple series of lime-soda glasses.

GLASS FOR LAMP-WORKING PURPOSES.—J. D. Cauwood, J. H. Davidson, F. W. Hodkin, and W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 266, 1919). An account of some experiments, including analyses of certain German, Austrian and French glasses. A discussion of results brings out several interesting points.

MAGNESIA-SODA GLASSES.—J. H. Davidson, F. W. Hodkin, and W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 275, 1919). A short report of an investigation of magnesia-soda glasses corresponding to the series of lime-soda glasses previously investigated.

In a number of respects magnesia resembles lime in the properties it bestows on glass. Thus with magnesia in large quantities the glass is not easy to melt. The lamp-working properties are much the same, and so far no striking difference has been observed between the chemical resistance of the two kinds of glass. The viscosity of glasses containing large quantities of magnesia is greater than that of corresponding lime glasses, and magnesia glasses also retain their heat longer. Magnesia glasses also show a lower coefficient of expansion for heat and a lower annealing temperature.

ANNEALING TEMPERATURES OF MAGNESIA-SODA GLASSES.—S. English and W. E. S. Turner (*J. Soc. Glass Tech.*, **3**, 278, 1919). Magnesia glasses are easier to anneal than corresponding lime glasses, that is, the former can be annealed at a lower temperature.

DEVELOPMENT OF VARIOUS TYPES OF GLASS.—C. J. Peddle (*J. Soc. Glass Tech.*, **4**, 3, 20, 46, 59, 71, 1920). A series of papers dealing respectively with the interaction of silica with soda and potash, lime and soda, lime and potash, lime and the two alkaline oxides, the last one being concerned with a comparison of soda-lime-silica glasses and potash-lime-silica glasses.

None of the glasses 100 SiO_2 (20 to 40) Na_2O—with 17 to 50 per cent. of Na_2O—would be of use for optical work. The same is true of glasses in which the Na_2O is wholly or partially replaced by K_2O.

The calculation of batches for optical glasses of given optical constants is explained (pp. 30—32). The modifications required for large-scale meltings are discussed; they are due to pot attack and volatilisation, especially the former. For any given batch of lime-soda-silica glass, the larger the melt the higher the refractive index of the final glass; (because less silica is added from the pot); also the larger the melt the better the colour and the lower the percentage of alumina in the glass.

All the glasses of the two types 100 SiO_2, (40 or 20) Na_2O, (5, 10, 15, 20, 30, or 40) CaO, can be founded at temperatures above 1300°C., and all attack pot clay. Increasing either CaO or Na_2O in these glasses causes increased pot attack, the Na_2O being the more corrosive. The density of the glass increases on increasing either CaO or Na_2O, the CaO having the greater effect per molecule added. The density is additive in character, but the relation is modified by the constitution of the glass, as equal additions of the same oxide do not cause equal increases of density. The refractive index increases with increase of CaO or Na_2O, the former producing the greater effect per molecule added. Refractive index is additive in character, but the additive relation is modified by the constitution of the glass. The total dispersion increases as the CaO or Na_2O increases. From the results obtained, many other glasses of given optical constants can be made.

When more than 72 per cent. of silica is present, there is a tendency for the glass to devitrify, silica separating out under certain conditions. Glasses of this type with more than 10 per cent. CaO and more than 20 per cent. Na_2O easily devitrify under favourable conditions. With less than 15 per cent. Na_2O, CaO may be added up to 15 per cent. before the glass shows a tendency to devitrify.

Water attacks these glasses, forming new insoluble compounds, the

attack increasing with the proportion of Na_2O.

The durability of the glasses is increased by addition of SiO_2 and CaO, and decreased by addition of Na_2O. All the glasses with more than 15 per cent. Na_2O become dim on long exposure to atmospheric conditions. The glasses with 40 Na_2O weather badly, and some have devitrification tendencies. The glasses with 20 Na_2O have devitrification tendencies on slow cooling, except those in the vicinity of the type 100 SiO_2, 20 Na_2O, 20 CaO; even these exceptions would only furnish glass with third-rate weathering properties.

Glasses in the vicinity of 100 SiO_2, 20 Na_2O, 20 CaO (containing up to 14 per cent. CaO) will be found quite useful for bottles, jars, etc. The modern tendency with the soda-lime-silica glasses is to use a batch too high in silica and soda and too low in lime. Glasses of about the composition indicated by the formula contain 70 to 72 per cent. silica, 15 to 16 Na_2O, and 12 to 14 CaO. Batches for the same would contain 700 to 720 parts sand, 250 to 275 sodium carbonate (58 per cent. alkali), and 250 to 214 limestone. The best batch would probably be 720 sand, 260 sodium carbonate, and 230 calcium carbonate, which would be easily and quickly founded, giving a soft working metal, and supplying a glass of superior weathering properties for ordinary everyday use. Using salt-cake instead of sodium carbonate, 350 parts would be needed instead of 260, with about 1 part of charcoal or powdered coal to every 20 of salt-cake.

All the glasses of the two types 100 SiO_2, (40 or 20) K_2O, (5, 10, 15, 20, 30, or 40) CaO can be founded at temperatures above 1300°C., and all corrode pot clay. The density, refractive index, and total dispersion are affected by changes of composition practically in the same way as the corresponding soda glasses. When more than 34 per cent. K_2O is present, devitrification can be easily induced. Solubility and durability change in much the same way as in the corresponding soda glasses. None of the glasses is of first-rate durability from an optical glass point of view, and all would be unsuitable for the best optical instruments. The relative effects of K_2O and Na_2O differ widely in some respects.

Similar glasses in which the alkali content consists of equal molecules of Na_2O and K_2O—that is, (20 or 10) Na_2O, (20 or 10) K_2O—behave similarly as regards changes of density, refractive index, total dispersion, and solubility. The glasses with 20 Na_2O, 20 K_2O, and containing more than 9 per cent. CaO can easily be devitrified. With 10 Na_2O, 10 K_2O, the CaO may reach 13 per cent. without devitrification, and there is no separation of silica in any of the glasses containing this proportion of alkalies, though 100 SiO_2, 10 Na_2O, 10 K_2O, 5 CaO contains more than 76 per cent. SiO_2. None of the glasses has a first-rate durability from an optical point of view. Glasses in the vicinity of 100 SiO_2, 10 Na_2O, 10 K_2O, 20 CaO, if the optical constants were required to be ($\eta_D = 1{\cdot}525$, $V = 59{\cdot}4$), could be used in instruments, particularly if they could be protected.

Comparing the soda-lime-silica glasses with the potash-lime-silica-glasses, it is found that from a molecular point of view the glasses of the series 100 SiO_2, 40 Na_2O, (5, 10, 15, 20, 30, or 40) CaO are all higher in density than the corresponding K_2O glasses, and the series 100 SiO_2, 20 Na_2O, x CaO are higher in density than the corresponding K_2O glasses when x is greater than 7 molecules. The glasses containing equal molecular quantities of Na_2O and K_2O have densities intermediate between those of the corresponding Na_2O and K_2O series. In glasses with equal percentages of Na_2O and K_2O respectively, the other oxide percentages being the same, the soda glass has the higher density. For equal percentages by weight of alkali, the soda-lime-silica glasses have a higher refractive index for the D line and a higher total dispersion than the corresponding potash-lime-silica glasses. In these glasses Na_2O is a better flux than K_2O when added in equivalent amount by weight, so that the glass with Na_2O has the lower melting point.

Devitrification is more easily induced in Na_2O glasses than in K_2O

glasses. Increase of silica in glasses with high CaO content tends to prevent devitrification, whilst increase of the alkali helps it. Addition of CaO improves glasses which tend to deposit silica, but addition of alkali may enhance the tendency to separation.

Of all the alkali-lime-silica glasses examined, the only ones which could be used for general work are 100 SiO_2, 20 Na_2O, 20 CaO, 100 SiO_2, 20 K_2O, 20 CaO, 100 SiO_2, 10 Na_2O, 10 K_2O, 20 CaO, and glasses in their near vicinity. Each of these can be expressed by the simpler formula 5 SiO_2, R_2O, CaO, The formula hitherto most generally accepted is the Benrath formula, 6 SiO_3, R_2O, RO, in which R_2O represents either or both of the alkaline oxides, and RO may be CaO, BaO, PbO, ZnO, or mixtures of them. The author considers the glasses 6 SiO_2, R_2O, CaO would be somewhat difficult to melt, and though slightly superior in durability to the 5 SiO_2, R_2O, CaO, glasses, would exhibit distinct tendencies to devitrification. Several batches are given.

GLASSHOUSE POTS.—C. W. Thomas (*J. Soc. Glass Tech.*, **4**, 107, 1920). A suggested improvement in the manufacture, to enable the inner surface of the pot to be worked upon when hard and tough. The proposal is, in the case of a covered pot made in two parts, to fit a jointing cushion of asbestos rope between the crown and the lower part of the pot, each being grooved to hold the packing in position. In a similar adaptation of an asbestos cushion for other work, it was found to make a thoroughly effective gas-tight and dust-tight joint.

OPTICAL PROPERTIES OF SOME LIME-SODA GLASSES.—J. R. Clarke and W. E. S. Turner (*J. Soc. Glass Tech.*, **4**, 111, 1920). Relates to investigations of the glasses 2 Na_2O, 6 SiO_2—Na_2O, CaO, 6 SiO_2. The refractive index for the D line is practically an additive property of the composition. The refractive indices undergo regular increases as CaO replaces Na_2O. The total and partial dispersions and values of V are practically constant throughout the series of glasses examined.

THERMAL EXPANSION OF MAGNESIA-CONTAINING GLASSES.—S. English and W. E. S. Turner (*J. Soc. Glass Tech.*, **4**, 115, 1920). The coefficients of expansion of a series of soda magnesia glasses were found to be an additive property of the composition. Replacement of soda by magnesia in a glass causes rapid diminution in the thermal expansion. Magnesia is much more effective than lime in reducing thermal expansion of glass.

COMPARATIVE EFFECTS OF SODA AND POTASH IN LEAD GLASS FOR TABLE WARE.—F. W. Hodkin and W. E. S. Turner (*J. Soc. Glass Tech.*, **4**, 120, 1920). The glasses tested were a commercial lead-soda glass and two other glasses in which equi-molecular proportions of soda and potash, and potash alone, were respectively substituted for the soda other than that introduced as borax. It was found that lead-soda glasses melt more readily than lead-potash glasses, and the lead-soda potash glasses more readily than either of the others. The lead-potash glasses are the most viscous and the lead-soda glasses least. Pot corrosion (as indicated by colour of glass) was most marked with soda glasses and least with potash glasses. About 2 parts borax per 100 parts sand in the batch has a notable beneficial effect on the durability of lead glasses. The soda-potash-lead glasses are much more durable than the others, and are preferable for all-round purposes.

DENSITY OF THE SODA-LIME GLASSES.—S. English and W. E. S. Turner (*J. Soc. Glass Tech.*, **4**, 126, 1920.) The results of tests prove that substitution of soda by lime in a glass increases density, and on plotting the results the density was found to be, approximately, an additive function of the composition.

PRESERVATION OF GLASS FURNACE REFRACTORIES BY WATER-COOLING.—E. B. Christmas (*J. Soc. Glass Tech.*, **4**, 128, 1920). Probably 90 per cent. of the open hearth furnaces for melting steel in the U.S.A. have Knox pressed and welded steel plate devices for the preservation of the

refractories. Similar devices are installed on heating furnaces, soaking pits, copper furnaces, puddling furnaces, glass melting furnaces, and electric furnaces. Such devices have more recently been used for steel melting furnaces in Great Britain and in Europe generally.

The water cooling arrangements for steel furnaces are first described briefly, and then the adaptation to Glass furnaces. The cooling action penetrates into the tank blocks for about 6 inches, and keeps the blocks from being reduced to a thickness less than about 4½ inches. As the blocks wear down to this point, the slight chilling effect experienced as far as 6 inches inwards from the outer wall will form a thin insulating layer, thus protecting the blocks from the various actions of the molten glass. It is possible to continue to operate the tank regardless of the thickness of the blocks. Should the blocks for any reason wear through (this is very important), the coolers act as a barrier, and the glass coming into contact with the cooled surface freezes, forming a wall of glass. The object of the coolers is to equalise the life and action of the weaker portions of the tank with that of the remainder. Some consider the division wall, others the dog house, side walls, etc., as the weakest part of a glass tank. The brickwork should be built thinner than without a cooler. By the time the thickness is reduced to 6 inches or even 4½ inches thick, the thinning will cease, and the surface of the wall will become glazed. Beyond this glazing further freezing would cease; the cooling only penetrated 4½ inches into the brick, therefore, freezing would take place between anything from 4½ to 6 inches, but would not go deeper.

IMPORTANCE OF ANALYSIS IN PURCHASING RAW MATERIALS FOR THE GLASS INDUSTRY.—A. Silverman (*J. Amer. Cer. Soc.*, **3**, 26, 1920). A strong plea for the control of the composition of glass through analyses of the raw materials used. Tables are given showing analyses of sands, soda ash, pearl ash, salt cake, nitre, limestones and limes (including dolomitic limestones), manganese dioxide, talc and felspar.

NOTES ON SHEET AND PLATE GLASS MANUFACTURE.—E. H. Bostock (*J. Amer. Cer. Soc.*, **3**, 35, 1920). A general review of progress and possibilities of development. The sheet glass industry was established early in the nineteenth century and wandered about for a century in the wake of cheap fuel—successively the wood of New Jersey and the New York lake regions, the bituminous coals of Pennsylvania, and afterwards the natural gas of Ohio, Pennsylvania, West Virginia, and latterly Kansas and Oklahoma. During this change of location, the only development of any great importance was the adoption of the Belgian tank system of melting in 1888.

John Lubbers (in 1894) conceived the idea of producing sheet glass mechanically, and eventually a commercially successful process was evolved. More recently, sheets have been drawn directly from the molten glass without any blowing or other intermediate process. Specialties in sheet glass have recently been made successfully.

The plate glass industry has shown more progress than most branches of the glass industry, doubtless owing to the larger scale of working.

Reference is made to various possibilities of development.

PRODUCER GAS AS FUEL FOR THE GLASS INDUSTRY.—F. J. Denk (*J. Amer. Cer. Soc.*, **3**, 94, 1920). A discussion of the costs of fuel in the forms of oil and producer gas, with a review of the different types of producer available, and means of increasing their efficiency.

CRAFTSMANSHIP IN FINE CUT GLASS.—J. J. Vallely (*J. Amer. Cer. Soc.*, **3**, 149, 1920). A discussion of the distinguishing features of good cut glass.

PRACTICAL TEST FOR RESISTANCE OF OPTICAL GLASS TO WEATHERING.—F. R. v. Bichowsky (*J. Amer. Cer. Soc.*, **3**, 296, 1920). The test of F. Mylins, determining the number of milligrams of adsorbed iodeosin per square metre—the surface alkalinity constant of the glass—is

described, but the results of this test should always be interpreted in conjunction with other tests. The other tests recommended are heating the glass to high temperatures with water, 5 per cent. solution of sodium hydroxide, and 1:1 hydrochloric acid, and noting the appearance of the surfaces, both when wet and when dry; the temperature was 225°C. for the first two, and 175°C. for the hydrochloric acid. The resulting appearances for different grades of glasses are discussed.

MECHANICS OF THE "WEATHERING" OF GLASS.—F. R. v. Bichowsky (*J. Amer. Cer. Soc.*, **3**, 309, 1920). A short note. The mechanism of the adsorption or absorption of water by fresh glass surfaces in general seems to consist of the following stages: (1) True adsorption of water on the surface; (2) diffusion or "solution" of the adsorbed water molecules into the body of the glass; (3) reaction of the dissolved and adsorbed water with the glass, forming a surface film of more or less thickness and of a character, depending on the composition of the glass; (4) Soaking up by this film of considerable amounts of water with consequent further reaction; (5) Extraction of the soluble salts (mostly the alkaline carbonates and hydroxides) from this surface film; (6) Solution of the silica skeleton film in the strongly alkaline solution formed. The several stages are briefly discussed.

The theory outlined for weathering with water is probably applicable to all weathering of glass, but the weathering due to other agents has not come under the author's experience.

CHOICE OF GLASS BATCHES CONTAINING LIME.—W. E. S. Turner (*J. Amer. Cer. Soc.*, **3**, 379, 1920). Batches with high lime content are still used in Europe, since they are eminently suitable for hand-working; they are used also with certain semi-automatic machines. For more modern machines the composition of the batch has been altered by reducing the lime and increasing alkali, as in Fettke's "lime-flint" glasses. The choice of a glass batch, especially with lime-soda batches, is very largely affected by the mode of working the glass. Glass with high lime sets quickly, and so is suitable for hand-working. Glasses with even more than 18 per cent. lime have been used for hand-blowing. But iron machines would chill glass fairly rapidly, and in the case of automatic flow or feed-device the orifice of the flow would tend to become choked through devitrification (often exhibited by glasses moderately high in lime). Hence for mechanical devices, bottle batches are now much softer, containing much less lime and correspondingly more alkali. The high soda and low lime glass melts much more readily, thus favouring accelerated production, the glass is softer and the bottles can be readily blown or pressed to the proper shape, and several bottles and jars can be collected to convey them to the lehr instead of having to transfer them much more quickly (as with high lime glass); automatic conveyors cannot be used so successfully with the high lime glass. The "lime flint" glass can be annealed more rapidly than high lime glass, because it requires a lower annealing temperature. High lime glass expands less on heating than lime-flint glass, but owing to its higher conductivity it cools rapidly. The disadvantage attending the higher expansion coefficient of the high soda glass is readily avoided by preventing entrance of draught in the lehr. The decrease in lime content is accompanied by decreased resistance to atmospheric and other chemical influences.

For general machine use, as well as for hand lime flint operations, the most satisfactory lime-soda glasses contain about 7·5 to 9·5 per cent. lime with about 17 to 15 soda and 75 silica; a smaller proportion of lime is not to be recommended.

TWENTY-THREE TYPES OF OPTICAL GLASS.—R. J. Montgomery (*J. Amer. Cer. Soc.*, **3**, 404, 1920). The main difficulty in making optical glass is in obtaining the required optical properties and at the same time so combining the constituents and handling the material that a good quality

of glass will result. Optical properties are now relatively easy to obtain, but in some cases it has been impossible, either in Europe or America, to obtain really good glass. Certain types are of poor colour and contain bubbles. From a study of published information combined with practical experience in the manufacture of optical glass the author finds that: (1) all the glasses may be plotted on squared paper with dispersions as abscissae and refractive indices as ordinates; (2) the glasses fall into natural groups in the field plotted, and may be divided into types according to composition; (3) there are 23 ordinary types of optical glass, each type embracing a number of glasses quite similar in optical properties, composition, and method of manufacture; (4) the components of the glasses fall into two divisions (*a*) fundamental oxides affecting the optical properties, and (*b*) control chemicals which affect the melting behaviour. The fundamental oxides are: SiO_2, K_2O, Na_2O, CaO, PbO, ZnO, B_2O_3, etc., while by the control chemicals are meant the proportioning of carbonates, nitrates, chlorides, and sulphates, or the use of As_2O_3 and Sb_2O_5 to obtain good melting conditions. The fields occupied by the various types of glass with refractive index 1·45 to 1·80 and dispersion 20·0 to 70·0 are shown in a diagram. The list is as follows:

1.	Borosilicate crown	13.	Barium light flint
2.	Borosilicate crown high dispersion	14.	Barium flint
3.	Crown of low dispersion	15.	Dense barium flint
4.	Light silicate crown	16.	Telescope flint
5.	Ordinary Crown	17.	Extra light flint
6.	Telescope crown	18.	Borosilicate flint
7.	Ordinary crown of low dispersion	19.	Ordinary light flint
8.	Soft silicate crown	20.	Ordinary flint
9.	Zinc silicate crown	21.	Dense flint
10.	Barium silicate crown	22.	Extra dense flint
11.	Dense barium crown	23.	Densest silica flint
12.	Densest barium crown		

In the States 12 of the 23 ordinary types have been made—Nos. 2, 5, 7, 11, 12, 13, 14, 16, 19, 20, 21, 22, A brief survey of the field is made, including indications as to the composition of many of the types.

GLASS MANUFACTURE.—G. E. Bateson and H. A. Bateson (*Pat. J.*, No. 1616, 1920). Pat. No. 134,801, Aug. 27, 1919. Relates to a modification of the bottle-neck-shaping mechanism described in Specification 8430/14.

GLASS MANUFACTURE.—T. J. McCoy (*Pat. J.*, No. 1616, 1920) Pat. No. 134,807, Oct., 11, 1918. Relates to apparatus for the production of sheet glass by allowing molten glass to flow continuously over a dam from a tank.

REINFORCED GLASS TUBES.—K. Kuppers (*Pat. J.*, No. 1617, 1920). Pat. No. 134,841, Nov. 4, 1919. Relates to the reinforcing of glass tubes by slipping a tube of wire gauze or a wire helix over a cylindrical core, sliding the glass tube on, and heating under reduced pressure.

GLASS FURNACES.—Fours et Procédés Mathy (*Pat. J.*, No. 1617, 1920). Pat. No. 135,115, April 14, 1919. Relates to a crucible glass furnace or oven constructed with a number of separate chambers arranged in rows, each chamber containing a crucible surrounded with fragments of porous refractory material; gas and heated air are supplied for flameless combustion.

GLASS MANUFACTURE.—R. E. McCauley (*Pat. J.*, No. 1619, 1920). Pat. No. 135,454, Jan. 6, 1919. Relates to apparatus for delivering molten metal of the kind described in specification 113,665 combined with a machine for moulding glass articles under pressure.

GLASS-MELTING FURNACES.—S. G. Curd (*Pat. J.*, No. 1619, 1920). Pat. No. 135,636, May 5, 1919. In a regenerative glass-melting furnace fired with producer gas, the producer gas is passed over a mixture of iron and

carbon before entering the furnace, to enrich and improve the heating qualities of the gas, and it is further enriched by mixing it with gaseous products such as hydrogen and carbon monoxide obtained by passing superheated steam over a similar mixture of iron and carbon.

GLASS-DRAWING APPARATUS.—A. L. Forster (*Pat. J.*, No. 1619, 1920). Pat. No. 135,697, Jan. 28, 1919. In drawing-apparatus of the kind in which sheet glass is drawn up between endless asbestos belts, rows of short spring-pressed rollers are employed to improve the grip of the belts on the glass. The use of short rollers is said to avoid breakage of the glass sheet. One of the bottom rows of rollers may be replaced by a flat plate, to assist in flattening the drawn sheet. Chain-mail may be incorporated in the belts to increase their strength.

GLASS BOTTLE MANUFACTURE.—A Dutch firm (Leerdam) (*Pat. J.*, No. 1621, 1919). Pat. No. 136,518, March 31, 1919. In a machine for making narrow-necked bottles, the parison and finishing moulds are arranged in pairs so that two bottles are blown at a time, the metal is forced down into the ring mould by compressed air, and the parisons are blown up against bottom moulds, or covers to the parison moulds, which covers also serve for the introduction of the compressed air into the parison moulds.

XI.—CEMENTS, MORTARS, CONCRETE, Etc.

MARBLE-LIKE ARTIFICIAL STONE.—H. Grönroos (*U.S. Pat.* No. 1,341,979, June 1, 1920.) An artificial slab of marble-like appearance is formed with a body portion of a fused mixture of equal amounts of porcelain or faience refuse, powdered pipe clay and crushed glass with a surface layer formed of porcelain refuse which is placed on the bottom of the mould in which the fusion is performed.

IRON PORTLAND CEMENT, WITH A CLASSIFICATION OF CEMENTS FROM BLAST-FURNACE SLAG.—E. H. Lewis (*Engineering*, **109**, 626, 1920). Cements made from blast-furnace slag are divided into 5 classes: (1) Blast-furnace slag as a cement, lime, silica and alumina as in portland cement, but in different proportions. This cement sets slowly. (2) Slag cements consist of granulated slag, plus lime, firmly ground together. Since the slag is not reburned, the S content is usually higher than in Portland cement. (3) Portland cement as ordinarily made, either from naturally occurring materials or from blast-furnace slag plus limestone. (4) Improved slag cement consists of granulated slag plus a proportion of Portland clinker burnt from a mixture of slag and limestone. The clinker addition improves the strength and setting time. (5) Iron Portland cement: granulated slag is added to Portland clinker during grinding and results in increased strength. In Germany, the quantity of slag added to the clinker cannot be greater than 30%. Sp. gr. of iron Portland cement averages 3·06. An average of several analyses gave insol, residue 0·25%, MgO 1·96, SO_3 2·35, ignition loss 1·00. Time of set can be regulated from a flash to slow by watching the composition of the clinker. A slag high in Al_2O_3 + a high CaO clinker will pass the soundness test. Iron Portland cement should be specially suitable for sea water construction, as the added slag protects any free CaO from the Mg salts which are apt to attack concrete made of Portland cement.

FLOOR HARDENER TESTS.—Bur. Standards (*Concrete*, **16**, **279**, 1920). A number of concrete floor hardeners classified under the four heads: (1) Mg. fluosilicates, (2) varnishes and paints, (3) waxes, and (4) miscellaneous, were applied to the floors of a Govt. lab. All tests made with class 1 gave good results, while the remaining three classes produced varying results.

REFRACTORY CEMENT.—S. A. McMinn (*U.S. Pat.* No. 1,341,510, May 25, 1920). A cement suitable for lining fire clay gas retorts is formed of powdered glass 33-42% and fire clay 67-58%.

CAUSE OF UNSOUNDNESS IN PORTLAND CEMENT.—B. F. Erdahl (*Concrete, Mill Sect.*, **16**, 83, 1920). Unsoundness of Portland cement is due to di-calcium silicate and not to free lime. One sample of sound and one of unsound clinker were heated, in presence of excess silica with an oxyacetylene flame, to a molten state for 20 min. Upon cooling, both samples "dusted." Analyses showed an excess of SiO_2. An over-limed unsound clinker heated in an iron ladle with gypsum rock to same temp. as above, showed by analyses an increase of lime and the resulting cement was sound. Under this condition the di-calcium silicate of the unsound cement had, because of the high burning temp. and an excess of lime, been converted to sound tri-calcium silicate. "Free lime is never the cause of unsoundness."

FIRECLAY MORTARS FOR LAYING FIRECLAY BRICKS.—R. M. Howe (*Chem. and Met. Eng.*, **23**, 232, 1920). A well illustrated article dealing with the composition of fireclay mortars. The paper is designed to show the effect of the addition of certain materials to the ground fireclay. The clay used in the experiments was very plastic and contained 56·42% silica, 28·46% alumina, 3·12% ferric oxide, and a little lime, magnesia and alkali. Its fusion point was cone 30. Different amounts of waterglass, salt, Portland cement, carborundum, asbestos and lime were added, and small samples of the mixtures were fused in the usual type of furnace. The results showed that the addition of only 5% of lime, cement, asbestos or salt lowered the fusion point by about 200°F. Waterglass and carborundum did not have such a marked effect. The combined effect of the action of asbestos and waterglass (about 10% of each), was to render the mortar very unsuitable for use under high temperatures. Owing to shrinkage, fireclay alone is not suitable as a mortar, consequently, the effect of adding clay which had already been shrunk was tried. It was found that a mixture one half clay and one half ground bats of first quality bricks gave very satisfactory results under high temperatures. It is pointed out that the joints should be as thin as possible.

MANUFACTURE OF ELECTRIC ACCESSORIES WITHOUT FIRING.—E. Probst (*Ker. Rund.*, **28**, 153, 1920). The enforced reduction in the output of porcelain owing to the shortage of coal in Germany, has led to the manufacture of various electric accessories (switches, etc.) out of materials such as magnesite cement, stone bodies, etc., which require no burning. The articles are made in hydraulic or hand presses, and the time required for setting is comparatively short.

PORTLAND CEMENT.—E. H. Hurry and H. J. Seaman, Pat. No. 10,958, 1901. Provisional and complete specifications for "Improvements in Process of Manufacturing Portland Cement and Apparatus therefor." An improvement on the process and apparatus described in the same inventors' Pat. No. 7139, 1900. The apparatus referred to is "a vertical furnace" or shaft kiln.

HYDRAULIC CEMENT.—H. E. Brown, (*U.S. Pat.* No. 1,124,238, Jan. 5, 1915) (Specification). Relates to improvements in processes of making hydraulic cement and more especially to a process in which useful potash or other alkaline metal salts may be obtained as a by-product. Felspar (orthoclase) or equivalent materials are used.

TESTING OF CLAYS FOR CONCRETE AGGREGATE.—D. H. Fuller (*J. Amer. Cer. Soc.*, **3**, 256, 1920). Relates to overfired clays and shales with vesicular structure, preferably with cavities small and numerous rather than large and few. The light product is useful for constructional work where it is desirable to keep the weight low without proportionate loss in strength. Quick firing under strongly reducing conditions constitute the test.

CONCRETES.—Harland & Wolff and A. Marks (*Pat. J.*, No. 1616, 1920). Pat. No. 134,598, Nov. 1, 1918. Relates to the use of mixtures, such as two parts Portland cement and one part sawdust, damped with sodium silicate solution and then wetted with calcium chloride solution.

POTASSIUM SALTS; CEMENTS.—International Precipitation Co. (*Pat. J.*, No. 1917, 1920). Pat. No. 134,920, Nov. 13, 1918. Relates to the recovery of potassium chloride in the production of Portland cement by adding sodium chloride or an alkaline earth chloride to the mixed material, or to the powdered material, or to both.

SLAKING LIME.—Spoerri & Co. (*Pat. J.*, No. 1618, 1920). Pat. No. 135,172, Oct. 27, 1919. Relates to an apparatus for slaking lime in which the lime is sprayed with water in a rotary sieve in a slaking-drum.

CONCRETES.—E. C. Bayer (*Pat. J.*, No. 1619, 1920). Pat. No. 135,476, Nov. 14, 1919. Pumice stone is rendered suitable for use in the manufacture of a light concrete for shipbuilding, etc., by crushing and heating to a temperature of about 1000°C. or higher up to the melting point, or the pumice may be heated before it is crushed.

CONCRETES.—D. Dale (*Pat. J.*, No. 1620, 1920). Pat. 136,075, April 16, 1919. A concrete is made by mixing together cement, sand, water, and feathers, preferably in the proportions of 1 part of cement to 3 parts of sand, the feathers being added in small quantities at frequent intervals.

XII.—ANALYTICAL PROCESSES.

DETERMINATION OF SILICA.—H. A. B. Motherwell (*Engineering Mining J.*, **103**, 1155, 1917). A discussion of the solubility of silica in chloride solutions, etc. The author states that "After five or six thousand Na_2O_2 fusions in nickel crucibles with some hundreds checked by the carbonate method in a platinum crucible I can speak for the accuracy and the speed of the former method."

From the quoted results of tests, the author deduces that arsenic, antimony, lead, bismuth, molybdenum, and vanadium do not interfere with the silica. Even lead sulphate does not remain with the silica unless in very large quantity. Tungsten is left with the silica, and so is barium when much sulphur is present. Titanium in small amounts does not interfere; in larger quantities it depends much on the thoroughness of the washing. Most writers and authorities state that TiO_2, or the most of it, is left with the silica. "A very long series of tests has satisfied me that this is not so with all ordinary amounts." Some data bearing on this last statement are furnished. It is added that a sample of magnetite with 8 per cent. TiO_2 showed only a trace of TiO_2 in the silica.

XIII.—INSTITUTES, EDUCATIONAL, HISTORICAL.

ANCIENT NORSE POTTERY.—K. Jacob (*Ker. Rund.*, **28**, 89, 1920). A short account of prehistoric pottery found in Denmark, dating back to 3000 B.C. The information and descriptions are taken from Dr. Sophus Muller's works on Danish archæology.

FAYENCES OF THE SIXTEENTH CENTURY.—H. Welte (*Sprech.* **52,** 225, 237, 245, 1919). A historical discussion of three German and French groups (Hirschvogel, Henri deux and Palissy) as distinct from the Italian Majolica.

UNION OF GERMAN-AUSTRIA WITH GERMANY FROM THE POINT OF VIEW OF THE GLAS INDUSTRY.—(*Sprech.*, **52,** 54, 1919). An Austrian manufacturer points out that, from a purely economic standpoint, union with Germany would mean little short of suicide for the Austrian industry.

THE ZINC INDUSTRY IN UPPER SILESIA.—F. Krantz (*Rev. Mét.* **9,** 577, 1912). A memoir on the development of the industry (extracts by M. Desmarets). It originated in 1565, in a very small way, but it was not until 1704, that it became really active, when a monopoly was granted which lasted until 1802. Ruberg may be considered as the true founder of this industry in 1800, his trials having been made at the Wessola Glass Works, of which he was the manager The progress of this important industry is traced up to 1910.

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